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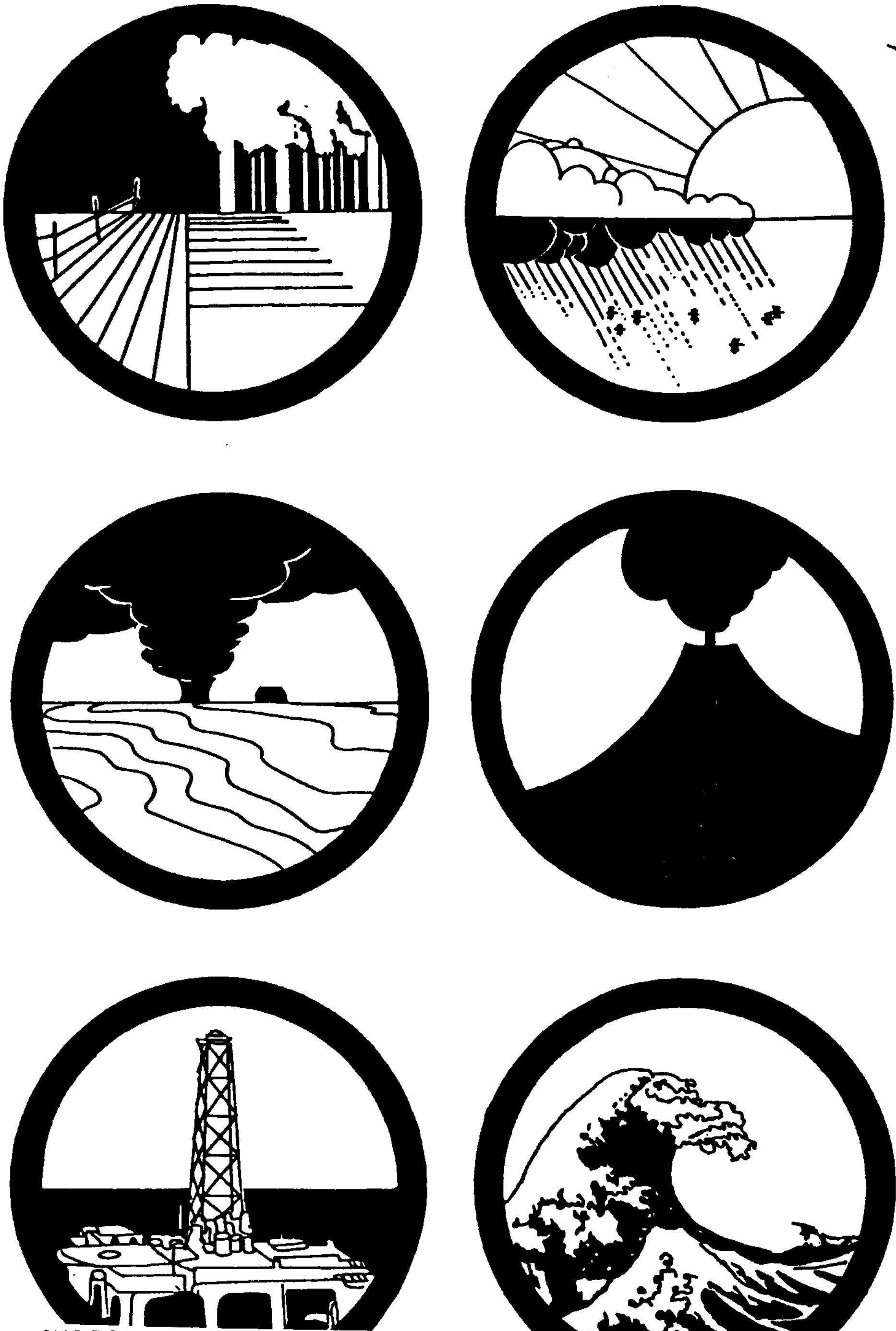
FINAL REPORT



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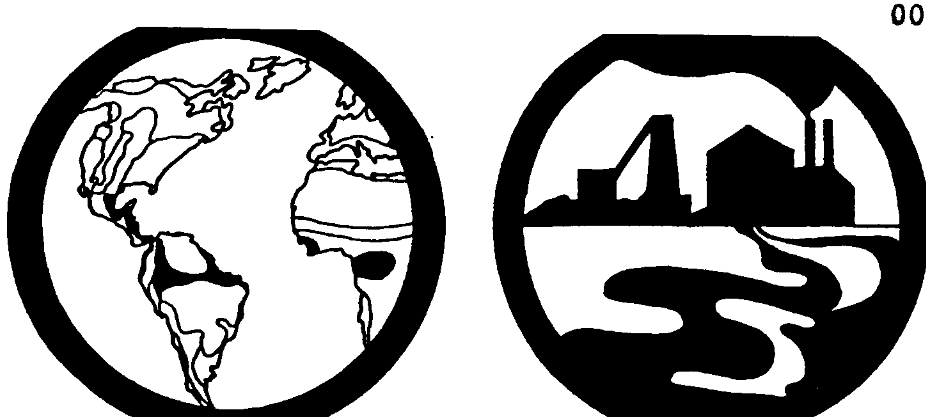

ECOSYSTEMS
INTERNATIONAL, INC.

NOVEMBER 1979 CONTRACT: NAS 5-25503

FINAL REPORT

APPLICATIONS DATA SERVICE USER REQUIREMENTS STUDY

BY

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FOREWORD

This is the Final Report on Contract NAS5-25503, "Applications Data Service User Requirements Study," performed for NASA's Goddard Space Flight Center by ECOsystems International, Inc.

The objective of this document is to present in summary form the requirements of NASA's research community for OSTA and related data; and to make visible the data's current availability, location, modes of query and manners of retrieval.

The OSTA research community is defined to include researchers internal to NASA, external investigators contracted by NASA e.g. Universities, researchers within Federal Agencies which have Memorandums of Understanding with NASA and which work cooperatively with NASA scientists, users working on Applications Systems Verification Tests (ASVT) and Application Pilot Tests (APT) cooperatively with NASA scientists researchers performing R&D under the Announcement of Opportunity (OA) and Applications Notice (AN) Programs.

In concert with NASA Project Management, OSTA's data-related activities were structured in thirteen disciplines, chosen to reflect OSTA's organization and mainlines of pursuit of scientific endeavors.

Inputs to the study were derived from approved NASA documentation on future plans, RTOP's, APT's, ASVT's, OA's, AN's and from specific written and oral inputs from NASA Center Discipline Scientists. These scientists also provided validation of the material, after it was organized and structured into the tabular and descriptive format shown in this Report. They are listed following. Their inputs are gratefully acknowledged.

Comments and suggestions arising from the Data Systems Planning Workshop, held at Wallops Island, VA, October 9-12, 1979 are reflected in this report to the extent to which they were made available by the respective Panel Chairmen.

ECOsystems wishes to express its sincere appreciation to the individuals listed on the Table below who contributed a great deal of time and information which was utilized in the preparation of this study.

DISCIPLINE	RESPONSIBLE CENTER	RESPONSIBLE SCIENTIST	GODDARD DISCIPLINE SCIENTIST	SCIENTIFIC CONTRIBUTORS
Global Weather	GSFC	Louis Allison	Louis Allison	Milton Halem (GSFC), Joel Susskind (GSFC), Ernie Neil (GSFC), Leland L. Dubach (GSFC)
Climate	GSFC	Otto W. Thiele	Otto W. Thiele	Milton Halem (GSFC), Joel Susskind (GSFC), Jay Zwally, Albert Arking
Severe Storms	GSFC	Louis Allison	Louis Allison	William E. Shenk (GSFC), Raymond A. Minzer (GSFC), Cynthis A. Peslen (GSFC), Edward B. Rodgers (GSFC), Ernie Neil (GSFC), Earl R. Kreins (GSFC)
Air Quality	LaRC	Howard Curfman	Louis Allison	Richard Steward (GSFC)

DISCIPLINE	RESPONSIBLE CENTER	RESPONSIBLE SCIENTIST	GODDARD DISCIPLINE SCIENTIST	SCIENTIFIC CONTRIBUTORS
Ocean Processes	JPL	Edwin Sherry	Vincent V. Salomonson	-
Coastal Zone	GSFC	Honsuk H. Kim	Honsuk H. Kim	-
Cryosphere	GSFC	Frank D. Carsey	Frank D. Carsey	Jay Zwally (GSFC)
Water Quality	LaRC	Howard Curfman	James P. Ormsby	-
Agriculture, Forestry, Rangeland	JSC	Chris C. Critzos	John L. Barker	-
Water Resources	GSFC	James P. Ormsby	James P. Ormsby	Albert Rango (GSFC), Thomas Schmugge (GSFC)
Land Use	NSTL	Armand Joyce	Darrel Williams	-
Non-Renewable Resources	JPL	Edwin Sherry	Richard J. Allenby	-
Geodynamics	GSFC	Stephen C. Cohen	Stephen C. Cohen	Guy M. Lohman (JPL)

Special appreciation is expressed to Mr. J. Earle Painter, Technical Officer; Richard des Jardins, Lottie Brown, ADS Project Office; Andrew Adelman, Assistant Director of Applications, Goddard Space Flight Center, Janeth Heuser and Howard W. Shaffer, NASA Headquarters.

This report summarizes the findings of the user requirements analysis.

The additional four-volume "Compendium of OSTA Space Data Usage Information," also prepared as part of this effort, contains detailed descriptions of user requirements, a Directory of space sensor characteristics and products, a Directory of Space and Auxiliary Data Bases, matrices correlating Space Missions, Platforms, Sensors, Parameters.

INTRODUCTION

This is the Final Report on Contract NAS5-25503, "Applications Data Service User Requirements Study," performed for NASA's Goddard Space Flight Center by ECOsystems International, Inc. The purpose of this report is to present the ADS technical drivers. The technical drivers were assessed from analyses derived from information from the OSTA research user community.

The appearance of remote sensing from space on the national scene almost two decades ago was accompanied by great expectations that the large coverage and frequent observations would allow a major step forward in the Nation's ability to manage its environment and resources.

Part of this expectation has now reached fruition, both in the reality of the space data themselves and from the stimulus of space derived data products and space technology to almost every facet of national activities concerned with managing our resources.

Progress toward full realization of the expected benefits of remote sensing from space could be accelerated by insuring that data are readily available to users in a timely manner and in the combinations, forms and formats necessary for their efficient utilization. In particular, it is essential that users be provided a means of acquiring combinations of remote sensing and conventional data in forms and formats which permit efficient data combination during the information extraction process.

Data lie in widely dispersed repositories; their formats differ significantly; their standards of quality are not unified; methods of delivery differ among data repositories; archiving agencies have differing operational requirements.

The objective of the Application Data Service (ADS) is to provide timely, affordable, accessible and readily usable multisource data products to applications researchers and user government agencies.

The scope of the ADS includes all users affiliated with the NASA Office of Space and Terrestrial Applications (OSTA), including mission agencies such as The National Oceanic and Atmospheric Administration (NOAA) and others with whom cooperative efforts are ongoing.

ADS will not itself be a data producer or user, but may provide necessary interfacing, translation and data assembly services to make producer data readily accessible and usable. ADS is intended to serve the OSTA applications research community and its cooperators. Its design will be expandable with an eye toward an eventual national service with a potential for commercialization.

The ADS plan is to meet future OSTA data access and integration needs by building upon existing and planned applications data systems. It will encourage the convergence of those systems and their products into a compatible and integrated structure, via a three-pronged approach:

- Definition of data and data systems standards

- Development of a network service for data transmission and integration

- Development of Data services

The standards will provide guidelines for future programs. Their definition and application will assure the natural evolution of future data and data systems compatibility.

As to the networks, available technologies range from conventional mail through electronic delivery, with access at designated data archives and delivery to user terminals. The network service will streamline that system's efficiency. It will provide a single service to access data, provide required format conversions and integrate the data sets required by multiple users.

Data services will include data directories and dictionaries which will guide the user in his data access efforts to data set assembly and reformatting which will relieve him of costly, time consuming preparation for his principal interpretational tasks. Directories of data manipulation and interpretation algorithms will be maintained and access to the algorithms will be provided by ADS.

An important consideration is the eventual implementation of ADS by private commercial enterprise. Closely related thereto, is the expected growth of technology, whose principal impact upon ADS is the reduction of costs and the increase of sophistication of data handling hardware and software foreseeable from such technological progress.

PURPOSE OF THE USER REQUIREMENTS STUDY

The study described in this report had as its objective the identification of OSTA users' data service requirements. The study was structured to answer the questions:

- Who are the users of the data within the NASA research community?
- What are the NASA OSTA uses?
- What data is required to support these uses and in what quantities?
- What space-derived data exist; from what sensors and platforms; with what characteristics?
- What applicable conventional data are available; where and how may they be acquired?
- How will the data uses, data generators, data banks and the user community change during the 1980's?
- What do the users perceive to be their data service needs for the next decade?

Answers to these questions will identify the performance elements needed of an Applications Data Service and permit them to be ranked on the basis of demand. They also provide gross sizing information for the systems required to provide the services.

Since economic considerations were not applied to the demand assessment, an impact/cost analysis of the identified services may be in order.

STUDY METHODOLOGY

For purposes of this study, OSTA activities related to remote sensing applications were categorized under thirteen discipline titles:

Air Quality	Agriculture, Forestry, Rangeland
Climate	Geodynamics
Coastal Zone	Land Use
Cryosphere	Non-Renewable Resources
Global Weather	Water Resources
Ocean Processes	
Severe Storms	
Water Quality	

The first eight address environmental observation concerns; the last five address resources observations.

Each discipline category was researched independently under the cognizance of the appropriate NASA center as well as the ADS Study Office.

The near term (1980-1985) and future (1985-1990) data related requirements of the OSTA research community users within the thirteen disciplines were derived from analysis of NASA plans and documents and information received from Discipline Scientists selected by NASA from within responsible centers. Documented plans of other federal agencies involved in programs pertaining to the OSTA disciplines were also used in projected future activities and requirements where a NASA programs relationship was indicated.

The diverse data requirements were normalized to reconcile differences in nomenclature, synthesizing the material into a common format for subsequent analysis. The resulting material was validated in three successive iterations by the Discipline Scientists and critiqued by Data Systems Planning Workshop participants, insuring the validity and traceability of all items.

Projection to the 1985-1990 time frame was accomplished by extrapolating the various research activities from best available internal and external evidence. As an example of the former, many RTOP's identify subsequent phases of their proposed program, even though funding is only available for the near term. As an example of the latter, certain activities can reasonably be expected to convert into operational endeavors -- to be performed by industrial users or other federal agencies. OSTA's corresponding R&D activities can be assumed to power-down on or about the projected date of technology transfer.

As in all projections, the accuracy of forecast is highest for the near term efforts. Nevertheless, the projections should reflect a reasonable structure of OSTA's program to the end of the coming decade when considered as a whole, barring significant breakthroughs or other radical redirections.

The conventional data bases currently in existence within the Federal Government and used by NASA/OSTA researchers were identified, assessed and categorized.

Detailed supporting information on each of the above subjects is contained in the four volume "Compendium of OSTA Space Data Usage Information" prepared by ECOsystems to support the OSTA Data Systems Planning Workshop. The "Compendium" contains a detailed description of user requirements, a directory of space sensor characteristics and products, a directory of space and auxiliary data bases, and matrices correlating space missions, platforms, sensors and parameters.

STUDY RESULTS

Results of the OSTA User Requirements Study for the thirteen disciplines are presented in five categories of requirements:

- Space Derived Products
- Space Derived Parameters
- Conventional Data Products
- Data Transfer
- Data Services

Space Derived Product Requirements

Table 1.1 summarizes the quantity of space derived products required for the thirteen disciplines for the current (1980), near term (1985), and future (1990) time frames. The table gives the number of digital tapes, corresponding data volume (gigabits), and images required by the users from spaceborne sensors expected to be available.

The key points from the table are:

- The volume of digital data products is relatively constant to 1985. The projected 250% increase by 1990 is paced by the Agriculture, Forestry and Rangeland (AFR) Discipline.

- The largest share of the data products, climbing from 34% of all requirements in 1980 to 68% in 1990, is also induced by AFR.

  Dominance by the AFR Discipline is attributed to the fact that this discipline is projected to reach an advanced state of technology transfer and will continue to rely heavily upon NASA facilities.

TABLE 1.1

DATA REQUIREMENTS SUMMARY - ALL DISCIPLINES

Year		GLOBAL WEATHER	CLIMATE	SEVERE STORMS	AIR QUALITY	OCEAN PROCESSES	COASTAL ZONE	CRYOSPHERE	WATER QUALITY	AGRICULTURE, FORESTRY RANGELAND	WATER RESOURCES	LAND USE	NON-RENEWABLE RESOURCES	GEODYNAMICS	TOTAL
1980	TAPES/YR.	1566	3362	4071	630	2984	2856	358	130	9308	598	977	1054	477	28391
	TAPE SEGMENTS/YR.	-	-	-	-	-	-	-	-	8160	-	-	-	-	8160
	IMAGES/YR.	-	-	-	100	-	-	-	240	16019	740	1810	292	-	19201
	IMAGE SEGMENTS	-	-	-	-	-	-	-	-	400	-	-	-	-	400
	FILMSTRIPS/YR.	-	-	-	-	30	360	-	-	-	-	-	-	-	390
	G BITS/YR.*	55	118	142	22	104	100	13	5	329	21	34	37	17	997
1985	TAPES/YR.	3070	4892	5307	790	3509	304	289	385	8017	1250	1601	1173	429	31016
	TAPE SEGMENTS/YR.	-	-	-	-	-	-	-	-	2565	-	-	-	-	2565
	IMAGES/YR.	-	-	-	100	-	-	-	300	3089	2392	1076	514	81	7552
	IMAGE SEGMENTS	-	-	-	-	-	-	-	-	400	-	-	-	-	400
	FILMSTRIPS/YR.	-	-	-	-	20	40	10	-	-	-	-	-	-	70
	G BITS/YR.*	107	171	186	28	123	11	10	13	283	44	56	41	15	1088
1990	TAPES/YR.	3090	5157	6186	550	4287	731	463	375	48604	1420	1532	1330	445	74188
	TAPE SEGMENTS/YR.	-	-	-	-	-	-	-	-	1640	-	-	-	-	1640
	IMAGES/YR.	-	-	-	100	-	-	-	450	7746	2360	1065	615	81	12417
	IMAGE SEGMENTS	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	FILMSTRIPS/YR.	-	-	-	-	20	60	10	-	-	-	-	-	-	90
	G BITS/YR.*	108	181	216	19	150	26	16	13	1702	50	54	47	16	2598

*1 G Bits = 1,000,000,000 Bits

- The trend in Land Use and Water Quality is also toward digital processing. During the 1980-1985 time frame, images account for $\simeq$65% of products by number. By 1985 this percentage drops to $\simeq$40% and remains relatively constant to 1990.

- The increase in the demand for digital data in the future reflects the expected increased sensor resolution, successful development of computer algorithms and increased user sophistication. The principal discipline affecting the change to digital processing is Agriculture/Forestry/Rangeland (AFR).

- The use of imagery in the Non-Renewable Resources (NRR) discipline (doubles by 1985) is attributed to the reconnaissance nature of NRR applications.

Space Derived Parameter Requirements

Most users wish to retain control of the development of algorithms for converting data into parameters. The development of such conversion algorithms drives OSTA's activities up to 1985-87.

The relationship between the OSTA disciplines, the parameters sought by the users and the space data generators is included in chart form in the pocket at the back of this report.

As shown in the chart, 137 parameters were identified in the analysis. Each parameter is used on the average by four disciplines. Commonalities are evident.

- Commonality of parameters among the thirteen disciplines portends potential benefits from a centralized data service which provides parameters to multi-disciplinary users using approved algorithms.

The chart also shows that the parameters sought remain substantially invariant. What does change are the sensor's characteristics; i.e., data contributing to parameter derivation are measured more effectively as time progresses. Processing algorithms also improve.

- The continuous existence of common parameters throughout the 1980-1990 time frame implies that investment by ADS in an algorithm-processing service should be cost effective.

Conventional Data Product Requirements

Table 1.2 summarizes the volume of conventional products required to support the OSTA users.

It specifies the requirements for digital tapes by density, i.e. 1600, 800, 556 Bits per inch (BPI) and the needs for photographic and hardcopy products. Products such as maps, computer printouts, reports and microfilmed records are included within the hardcopy products category. The table's key points are:

- The volume of conventional data is approximately 30% that of the space data for this 1980-1985 time period. It increases to 50% by 1990.

- The Agriculture, Forestry and Rangeland Discipline is the primary user of conventional data, accounting for 73% of the requirements in the 1980-1985 time frame, increasing to 90% by 1990.

- The Severe Storms and Climate Disciplines are also significant users; 16% of the volume in the 1980-1985 time frame.

TABLE 1.2

ADS CONVENTIONAL DATA REQUIREMENTS SUMMARY - ALL DISCIPLINES

Year		GLOBAL WEATHER	CLIMATE	SEVERE STORMS	AIR QUALITY	OCEAN PROCESSES	COASTAL ZONE	CRYOSPHERE	WATER QUALITY	AGRICULTURE, FORESTRY RANGELAND	WATER RESOURCES	LAND USE	NON-RENEWABLE RESOURCES	GEODYNAMICS	TOTAL
1980	TAPES/YR. (1600 BPI)	300	38	788	14	13	12	13	0	1446	0	0	0	0	2624
	TAPES/YR. (800 BPI)	137	517	489	138	50	56	39	71	10697	145	72	73	224	12708
	TAPES/YR. (556 BPI)	0	420	0	0	122	102	160	0	0	0	0	0	0	804
	PHOTOS/YR.	0	0	0	0	0	0	0	0	0	0	220	0	0	220
	HARDCOPY	15	53	0	88	1	44	293	143	3310	134	158	77	61	4377
	G BITS/YR.	13	15	36	3	3	3	3	1	238	3	1	1	4	324
1985	TAPES/YR. (1600 BPI)	584	55	1043	18	15	1	10	0	1232	0	0	0	0	2958
	TAPES/YR. (800 BPI)	267	749	647	176	59	6	30	185	9113	304	119	81	198	11934
	TAPES/YR. (556 BPI)	0	609	0	0	144	11	123	0	0	0	0	0	0	887
	PHOTOS/YR.	0	0	0	0	0	0	0	0	0	0	362	0	0	362
	HARDCOPY	29	77	0	112	1	5	225	372	2820	281	260	85	54	4321
	G BITS/YR.	25	22	48	4	3	0	2	3	203	5	2	1	3	321
1990	TAPES/YR. (1600 BPI)	589	58	1204	12	19	3	16	0	7448	0	0	0	0	9349
	TAPES/YR. (800 BPI)	269	789	747	119	72	15	48	185	55101	345	114	93	211	58108
	TAPES/YR. (556 BPI)	0	641	0	0	176	27	197	0	0	0	0	0	0	1041
	PHOTOS/YR.	0	0	0	0	0	0	0	0	0	0	349	0	0	349
	HARDCOPY	29	81	0	76	1	11	361	372	17050	319	251	98	57	18706
	G BITS/YR.	25	24	55	3	4	1	4	3	1225	6	2	2	4	1358

BPI = Bits per inch

G Bits = 10^9 binary digits

Table 1.3 shows the data bases identified in the analysis. It shows that most data bases serve multiple disciplines; many already possess or are evolving towards the capability for electronic inquiry. By 1985, most major data repositories are contemplating various levels of automated data delivery. This does not mean that historical data will be necessarily digitized. Most of the data provided will be of current vintage.

In general, the data will be supplied in the batch mode. Most data bases provide only restricted access. This should, however, not pose a significant restriction to NASA access.

Directory and access services for a significant number of data bases is through three principal existing auxiliary data banks; Environmental Data & Information Service (EDIS), U.S. Geological Survey National Center (USGS National Center), National Water Data Exchange (NAWDEX).

- NAWDEX - Central point of access for most federal and non-federal water data banks such as STORET, WATSTORE, and various state and private data banks.

- USGS National Center - Central point of access to most USGS data services including EROS, NCIC, WATSTORE, and many smaller but frequently used data bases.

- EDIS - The Environmental Data and Information Service of NOAA provides computerized referral to available environmental sciences data at NCC, NODC, NGSDC and many other NOAA operated data banks.

TABLE 1.3

REMOTE DATA ACCESS CAPABILITIES OF THE DATA BANKS SERVING THE ADS DISCIPLINES

	AGRICULTURE	AIR QUALITY	CLIMATE	COASTAL ZONE	CRYOSPHERE	GEODYNAMICS	LAND USE	NON-RENEWABLE RESOURCES	OCEAN PROCESSES	SEVERE STORMS	WATER QUALITY	WATER RESOURCES	GLOBAL WEATHER	REMOTELY ACCESSIBLE DATA DIRECTORY	REMOTE DATA DELIVERY
Goddard Institute of Space Science (GISS)	●													R	R
Goddard Space Flight Center, Image Processing Division (GSFC/IPD)	●	●	●	●	●		●	●	●	●	●	●	●	R	R
Goddard Space Flight Center Very Long Baseline Interferometry System (GSFC/VLBI Systems)						●								D	D
Johnson Space Center, Agricultural Weather Forecasts (JAWF)	●													R	R
Jet Propulsion Laboratory Seasat Central Data Handlins Facility (JPL/SEASAT CDHF)			●	●	●	●	●	●	●	●		●		R	R
Jet Propulsion Laboratory Very Long Baseline Interferometry System (JPL/VLBI Systems)						●								N	N
Johnson Space Center Global Agronomic Data Base (JSC/GADB)	●													R	R
Aircraft Flight Programs NASA/JPL-WFC	●													N	N
National Space Science Data Center (NSSDC)	●	●	●	●	●	●	●	●	●	●	●		●	N	N
UARS Central Data Handling Facility UARS CDHF		●	●											R	R
DMSP Satellite Data Library (DMSP)				●					●					R	R
Earth Resources Observation System Data Center (EROS)	●	●	●	●		●	●	●			●	●		R	R
European Space Operations Center, Data Services (ECOS)													●	N	N
National Climatic Center, Space Data Services Branch (NCC/SDS)	●	●	●	●	●				●	●		●	●	R	R
NOAA, National Environmental Satellite Service (NOAA/NESS)	●	●	●	●	●		●	●	●	●	●	●	●	R	R
National Oceanic Satellite System, Primary Processing Facility (NOSS/PPF)			●	●	●	●		●	●	●	●		●	R	R

D - Dial-up Service Available
R - Restricted Access
N - Capability Does Not Exist
● - Discipline Served

TABLE 1.3 (cont'd)

REMOTE DATA ACCESS CAPABILITIES OF THE DATA BANKS SERVING THE ADS DISCIPLINES

	AGRICULTURE	AIR QUALITY	CLIMATE	COASTAL ZONE	CRYOSPHERE	GEODYNAMICS	LAND USE	NON-RENEWABLE RESOURCES	OCEAN PROCESSES	SEVERE STORMS	WATER QUALITY	WATER RESOURCES	GLOBAL WEATHER	REMOTELY ACCESSIBLE DATA DIRECTORY	REMOTE DATA DELIVERY
NASA/JSC AIRP-AID	●													R	R
National Cartographic Information Center (NCIC)	●						●	●						R	R
National Center for Atmospheric Research		●	●										●	R	R
National Climatic Center (NCC)	●	●	●	●	●			●	●	●	●	●	●	R	R
National Geodetic Data Base						●								R	D
National Geophysical and Solar Terrestrial Data Center (NGSDC)			●			●			●					R	N
National Hurricane Center (NHC)									●	●			●	R	R
U.S. Air Force Environmental Technical Application Center (USAFETAC)			●							●			●	R	R
U.S. Coast Guard Oceanographic Unit (USCG)										●			●	D	D
USDA/Economics, Statistics and Cooperative Service (USDA/ESCS)	●													R	D
USDA Foreign Agriculture Service (USDA/FAS)	●													N	D
USDA Scientific and Education Administration (USDA SEA)	●											●		N	D
USDA Soil Conservation Service (USDA/SCS)	●		●		●			●				●		N	R
USDA Forest Service USDA/FS)	●											●		R	R
USDA Agriculture, Stabilization & Conservation Service (USDA/ASCS)	●						●	●						R	D
Electric Power Research Institute (EPRI)		●												N	N
Fleet Numeric Weather Central (FNWC)			●		●				●	●			●	R	R
Fleet Weather Facility (FWF)					●				●				●	R	R
USGS/Geolab						●								R	R
GISS	●													R	R
JAWF	●													N	N
JSC/Agristars Data Base	●													R	R
LARS	●													R	R
Office of Water and Hazardous Materials (STORET)	●	●									●	●		R	R

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TABLE 1.3 (cont'd)

REMOTE DATA ACCESS CAPABILITIES OF THE DATA BANKS SERVING THE ADS DISCIPLINES

	AGRICULTURE	AIR QUALITY	CLIMATE	COASTAL ZONE	CRYOSPHERE	GEODYNAMICS	LAND USE	NON-RENEWABLE RESOURCES	OCEAN PROCESSES	SEVERE STORMS	WATER QUALITY	WATER RESOURCES	GLOBAL WEATHER	REMOTELY ACCESSIBLE DATA DIRECTORY	REMOTE DATA DELIVERY
Air Force Global Weather Central (AFGWC)			●						●	●			●	R	R
California Institute of Technology						●								R	R
Center for Climatic and Environmental Assessment (CCEA)			●											R	N
Current Research Information System (CRIS)	●													D	D
Defense Mapping Agency Topographic Center (DMATC)	●					●	●	●						R	R
Bureau of Census, User Services Office							●							N	N
EPA Environmental Research Center (EPA/ERC)		●												R	D
National Marine Fisheries Service (NMFS)			●	●	●				●		●		●	D	D
National Meteorologic Service (NMC)	●		●						●	●			●	R	R
National Oceanographic Data Center (NODC)			●	●					●		●		●	R	D
National Severe Storm Forecast Center (NSSFC)										●			●	R	D
National Severe Storm Laboratory										●			●	N	N
NOAA/Data Buoy Office (NBDO)									●				●	N	R
National Water Data Exchange (NAWDEX)											●	●		R	R
SEDIC														N	N
Scripps Institute of Oceanography									●					N	N
Tamu Crop Spectra Data Base (TAMU)	●													R	R
USGS Office of Resource Analysis (USGS/ORA)								●						R	R
USGS Rock Analysis Storage System (USGS/RASS)								●						R	R
USGS Water Storage Coordination Office (WATSTORE)								●			●	●		R	R
U.S. Weather Service							●			●		●	●	R	R
Weslaco Crop Spectra Data Base	●													N	N
Woods Hole Oceanographic Institute (WHOI)				●					●					N	N

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R - Restricted Access
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Data Transfer Requirements

The user requirements for data transfer are of the order of two to four weeks for research efforts and from hours to days for activities related to the transfer of technology.

Current data delivery times are of the order of one to three months. Note, however, that most of the current delay is attributable to internal response times. These will presumably be significantly reduced as data bases become increasingly automated in accordance with currently established plans.

By 1990, research activities account for approximately 75% of the data load. They could, in theory, be handled by mail type data transfer service. The slow data delivery requirements of the research activities do not necessarily connote that electronic linkages are not desirable. They simply indicate that the choice of the link is driven by economic cost-effectiveness rather than by technical urgency. A plausible ADS scenario might incorporate a centralized accounting, scheduling and data traffic monitoring facility which maintains track of expenditures on the part of the users; supplies them budgetary estimates; advises them of impending depletion of project funds. Further analysis might reveal that such a centralized management function can be performed more cost-effectively through the use of electronic data links rather than through other conventional alternatives, quite apart from considerations of speed.

A gross sizing of the "electronic link" alternative is provided by Tables 1.4 and 1.5.

TABLE 1.4

DISCIPLINE/CENTER ALLOCATION OF PRODUCT DATA FLOW FOR

SPACE AND AUXILIARY DATA AVAILABLE IN DIGITAL FORMAT - 1980, 1985, 1990

(Equivalent 1200 BPS Links, One Shift, Normal Workweek)*

DISCIPLINE	GSFC			JSC			JPL			LaRC			NSTL		
	1980	1985	1990	1980	1985	1990	1980	1985	1990	1980	1985	1990	1980	1985	1990
AIR QUALITY										3	4	3			
CLIMATE	15	22	23												
COASTAL ZONE	12	2	3												
CRYOSPHERE	2	2	3												
GLOBAL WEATHER	8	15	15												
OCEAN PROCESSES							12	14	18						
SEVERE STORMS	20	26	31												
WATER QUALITY										1	2	2			
AGRICULTURE, FORESTRY, RANGELAND				63	54	326									
GEODYNAMICS	3	3	3												
LAND USE													4	7	7
NON-RENEWABLE RESOURCES							5	5	6						
WATER RESOURCES	3	6	7												
TOTAL	63	76	82	63	54	326	17	19	24	4	6	5	4	7	7

* Number of Links = (data bits per year) ÷ (seconds per year) ÷ (1200 BPS per link)

Since the driver is economics, not technology, system tradeoffs can exploit to the fullest special tariff structures and price breaks; e.g. discounts for off-time operation, quantity savings from use of bulk bandwidths, use of satellite links; however, transfer distance exceeds the cost of the breakpoint (currently of order 900 kilometers).

By 1990, technology transfer activities account for approximately 25% of the data load. These latter could acquire two forms: 1) algorithms and models developed by NASA researchers are tested by other federal agencies upon their facilities; or 2) they are tested on NASA facilities with participation from sister agency personnel.

TABLE 1.5

ALLOCATION OF PRODUCT DATA FLOW FOR SPACE AND AUXILIARY DATA AVAILABLE IN DIGITAL FORMAT
(Equivalent 1200 BPS Links, One Shift, Normal Workweek)

	1980	1985	1990
GSFC	63	76	82
JSC	63	54	326
JPL	17	19	24
LaRC	4	6	5
NSTL	4	7	7

The first form of transfer does not impact ADS because by current definition, ADS is intended to service NASA researchers only. In the second event, the timeliness requirements for data transfer approach real time. It is, however, important to distinguish between the direct transfer of space data from satellite to users, and the transfer to users of archival data. Only the latter is within the purview of ADS as currently defined.

The activities posing the most stringent requirements are agricultural early warning and activities associated with crop production forecasting. The timings of the corresponding physical observables are such as to give rise to short periods of intense interest, interspersed by longer intervals of lesser importance. The occurrence of frosts is a typical case in point. Indicative crop change occurs within hours, at most a few days after the frost event. Thereafter, the "indicators," pointing to either recovery or loss, vary but slowly.

The net result is that these activities impact ADS by imposing conditions of high peak transfer rates at low duty cycles. As a gross sizing, peak-to-average ratios are expected to reach 5:1.

ADS systems tradeoffs can exploit the significant difference between the "slow" R&D and the "fast" technology transfer requirements through the use of load-evening techniques, such as priority scheduling.

Data Service Requirements

Table 1.6 summarizes the user response to the need for data services. The numbers indicate the percentage of users within each discipline specifying the data services shown on the corresponding row. Figure 1.1 summarizes this information across disciplines. The user requirements are weighted by the number of users served, assigning equal weight to each discipline user.

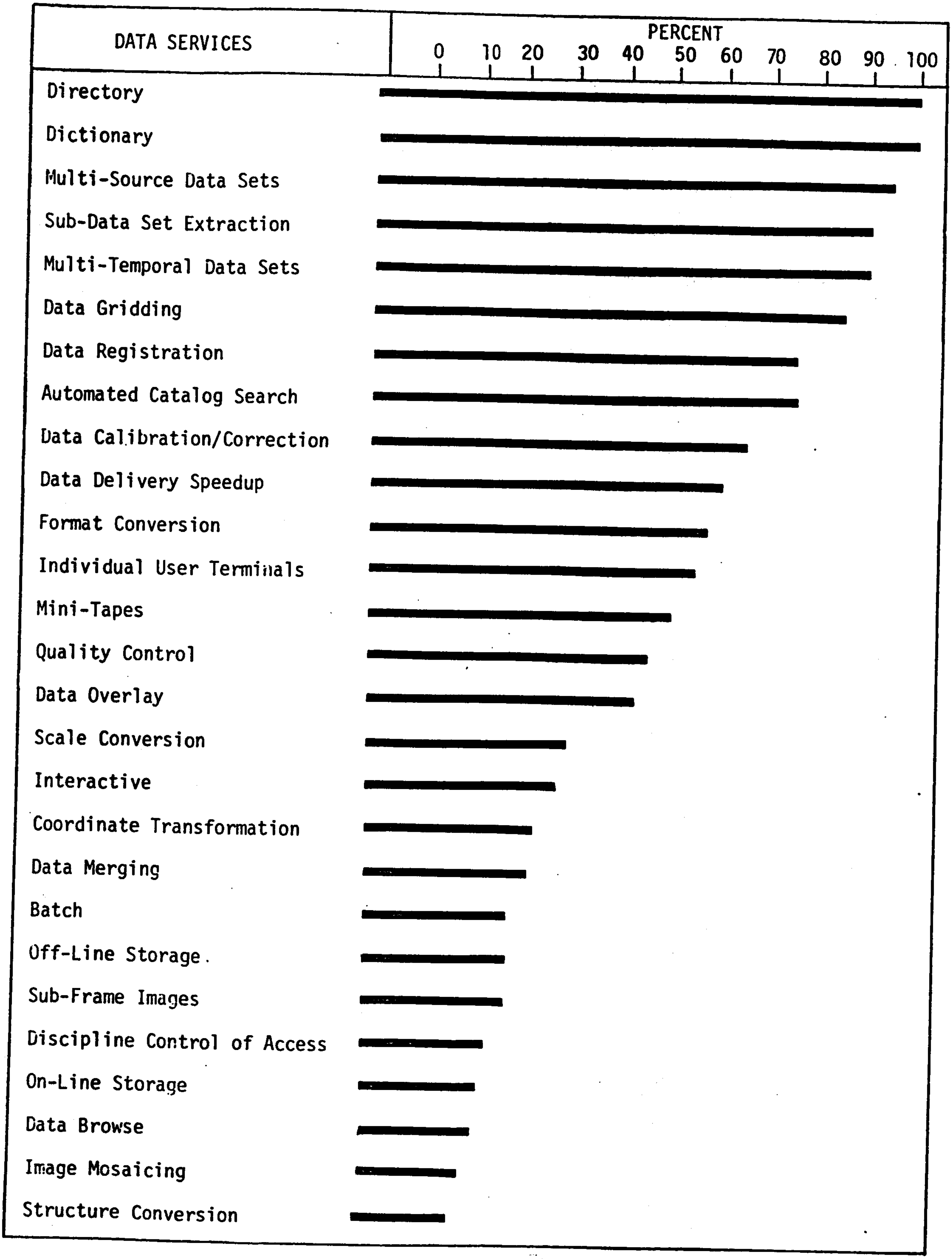
SUMMARY OF DATA SERVICES* REQUIRED BY OSTA INVESTIGATORS WITHIN THE THIRTEEN ADS DISCIPLINES

DATA SERVICES	PERCENT OF DISCIPLINE INVESTIGATORS REQUIRING THE SERVICE												
	AIR QUALITY	CLIMATE	COASTAL ZONE	CRYOSPHERE	GLOBAL WEATHER	OCEAN PROCESSES	SEVERE STORMS	WATER QUALITY	AGRICULTURE, FORESTRY, RANGELAND	GEODYNAMICS	LAND USE	NON-RENEWABLE RESOURCES	WATER RESOURCES
User Access Mode													
Batch								35		100		100	
Interactive	100	100					100						
Individual User Terminals	100		96	75	100	78	100			100		100	100
Data Management													
Data Documentation													
Directory	100	100	100	100	100	100	100	100	100	100	100	100	100
Dictionary	100	100	100	100	100	100	100	100	100	100	100	100	100
Data Storage													
On-Line	100												
Off-Line		100		20		22	96						
Product Control													
Quality Control		11	100	80		100				100	100	100	100
Data Access Services													
Data Query													
Automated Catalog Search	100	100	100	80		100		100		100	100	100	100
Data Browse		100											
Data Delivery Speedup			95	75	100	78	100	100		100	100	100	100
Value Added Services													
Data Segment Preparation													
Sub-Frame Images									100				
Mini-Tapes		11	100	80	60	61	100	100	100				100
Sub-Data Set Extraction	100	70	100		60	100	96	100	100	100	100	100	100
Reformatting													
Format Conversion			100	100	25	74	92	100		100	100	100	100
Structure Conversion					25		92						
Coordinate Transformation		11			25	22	92			100	9	100	
Scale Conversion									100	37	100		
Data Set Preparation													
Multi-Source Data Sets	100	91	100	80	100	100	96	100	100	100	100	100	100
Multi-temporal Data Sets	100	91	96	75	100	100	96	100	100	100	100		83
Data Integration													
Data Merging	22	36		100	85						100		
Data Registration	58	68	96	20	40	100	100	100	47	73	100	100	100
Data Overlay	33	59			15				00		100		100
Data Gridding	100	100	85	95	100	100	96	100		100	100	100	100
Image Mosaicing											100		
Special Processing													
Data Calibration/Correction	100	20	100	80	100	78	4	100	86		100		100
Discipline Control of Access	20										100		

*Services listed are not necessarily unique.

FIGURE 1.1

SYNOPSIS OF DATA SERVICE REQUIREMENTS - ALL DISCIPLINES



The key points indicated by the Figure are:

- ADS services universally required are:
  - Data directory services
  - Data dictionary
  - Preassembly of data sets from multiple sources
- Second Priority services are:
  - Extraction of selected data subsets from available data sets, for both space and auxiliary data products.
  - Assembly of multitemporal data sets.

  Users expressed significant demand for individual terminals. Approximately half of these should be interactive; a substantial fraction should be of the "smart" variety.

Users place significant emphasis on services related to the combination and integration of data - e.g. geocoding, superposition of format and gridding. The Air Quality users in the UARS program and the Geodynamics users specified the wish to retain control over access of their data by other users.

Additional services required by individual disciplines yielded the following ADS service requirements:

- Data ordering and procurement services are useful adjuncts to the catalog and inventory service. Currently, investigators gather their required data from a wide variety of basically unarchived and unannotated sources. Dealing with a variety of data banks is time consuming. The users universally express the need for a centralized facility from which they can locate and acquire the bulk of the data which they require.

- Data are available in a variety of formats which require co-registration. Proliferation of different formats unnecessarily increases overhead related to reformatting by both investigators and data system.

  ADS could significantly impact this problem by limiting the proliferation of varying data formats to those necessitated by efficiency or by compatibility with existing systems.

- Remotely sensed data products are generally viewed by operational users as supportive and complementary to the more readily understood and handled conventional data sets. Increased emphasis should be devoted to converting satellite data products into conventional formats to aid technology transfer activities. Satellite products should be processed and georeferenced in accordance with the conventional data products which they supplement.

An ADS service would significantly enhance the day to day operation of the OSTA research user community by:

- Speeding up data delivery - slow data deliveries impact the budget and the efficiency of the R&D effort.

- Eliminating or significantly reducing the time spent in locating, selecting, editing and procuring data.

- Reducing expenditures for redundant handling of data products

- Providing pre-operational users with standard, approved, parameter and analysis algorithms.

- Creating a highly visible and easily accessible archive of space derived products for both internal researchers and external users.

- Significantly increasing the cost-effectiveness of OSTA data utilization through standardization of format and the availability of researcher specified reformatting.

STUDY CONCLUSIONS

Results of the ADS User Requirements Study make a convincing case for the establishment of such a service. It seems clear that the ability of the space data user to successfully apply the data would be greatly enhanced by an ADS.

The specific services desired by the OSTA users without overall economic analysis were identified by the study. These potential ADS services which would contribute to the overall efficiency of OSTA research are:

- A data cataloging service would speed data access and would enhance investigators' awareness of data to support their studies. The catalogs should be comprehensive as to breadth and content of information in each data set. Hierarchial descriptors should be provided to accommodate various levels of user required data. The initial access level would contain the generic identification (e.g. name, source, location, period of record, measured or derived quantities/parameters) for each data set.

  Subsequent hierarchial levels would enable potential data users to browse and review the data set contents. Information at this level should include data set characteristics, such as resolution and level of reduction; quality control steps applied; data limitations and restrictions on data set usage, data volume and form, data availability for a specific location and appropriate cross-references to related data sets.

The next level of information should include detailed descriptions of instrument operations, data collection procedures, processing algorithms, and validation results.

Catalogs should also be available to identify available software routines, and data interpretation/manipulation tools and techniques.

Discussion at the ADS workshop indicates that such a catalog service would be best implemented in a distributed manner. Separate catalogs should be maintained by the individual data producer archives, with access capability from a central catalog facility. The distributed nature of the catalog service should be as transparent to users as possible. A user-oriented interface for obtaining catalog information should be a major objective of an ADS. This requires that an access/query capability be designed for ready use by even uninitiated users. A request processing capability should provide the contact point for initial inquiries. A request routing capability should be provided internal to the system but it should be user-transparent.

Key issues of importance that must be resolved during the development of an ADS catalog service are:

- Establishment of standards
- Generation of catalog contents for past data and updating procedures for current data.

- A parameter extraction/assembly service would reduce the time and expense required by researchers in acquiring and integrating the multi-source data sets. This service would provide standardized multi-source and multi-temporal data set preparation, data set sorting and merging, and data segment preparation. Important facets of this service are data reformatting and integration services.

Reformatting entails conversion of data from one form (digital, analog, textual, tabular or graphic) to another to satisfy user requirements. Also included are code, coordinate and scale conversions.

Data integration entails elements of both data set preparation and reformatting. Potential processing operations required to convert disparate data to a common form and scale include:

a) Multi-sensor, unitemporal and multitemporal registration, entailing the congruencing and rescaling of data of different scale and aspect angles;

b) Geographic referencing;

c) Coordinate transformations, for example, space oblique mercator to universal transverse mercator;

d) Data overlay and gridding;

e) Mosaicking, in which adjacent swaths of space or airborne imaging sensors are equalized radiometrically, congruenced, rescaled, and laterally registered.

- Centralized accounting, scheduling and data traffic monitoring serve to maintain track of user's expenditures and to supply budgetary estimates.

- Centralized facilities for processing data into parameters. Development of parameter processing techniques should be handled as a phased program, for key time persistent parameters. The capability for scientific visibility, data quality control assessment and parameter algorithms development and archiving should also be provided.

- Data delivery to users in user requested format with a factor of three speed up for conventional products.

- Establishment and maintenance of an archive of products derived by OSTA discipline researchers. The archive should provide data cross-referencing and should be constructed to serve both the internal and external user community. Archives should include browse, on-line order transaction and message processing capabilities.

- Establishment of comprehensive data format, standards and protocols particularly required for the processing of multi-source data sets.

- Provision for standard on-line and batch processing of requested data including specific data reformatting, resampling, and radiometric correction.

- The ADS service should be electronically linked into the major auxiliary data systems services; in particular, EDIS, USGS National Center and NAWDEX.

- The nature of many of the OSTA disciplines makes it advantageous to provide an archive of processed intermediate products, both to support multiple investigations and for historical purposes.

- The availability of standard classification schemes and parameter extraction algorithms from a centralized facility would enhance researcher performance. The various classification algorithms and procedures should be carefully annotated as to input requirements and utility, and should provide appropriate caveats as to applicability, time to process and expected performance accuracies. An interactive user-training capability would probably be a useful adjunct. The facility would have to maintain continuous updates on classification schemes and algorithms and process online.

- Acquisition processing and delivery of historical data is of great importance to several disciplines, the most notable of which is Climate. The ADS should establish the historical data service function.

2. INTRODUCTION

In the 1980's applications are moving into a new era of maturity where effective use and manipulation of multiple source data are key to applications success.

NASA is entering an era of large scale modeling, tackling applications which require the timely access and integration of data from multiple sources. Since each of these sources may in fact have its own access protocol and product form, such integration frequently requires the development of extensive access and conversion capability.

The Application Data Services (ADS) concept has risen from the recognition, through a decade of research, that the quality achievable from space data can be significantly enhanced by combining them with other data, either derived from complementary space sensors, or obtained from supplementary conventional sources.

Moreover, it appears that a considerable cost savings to NASA could be achieved by taking advantage of the commonality of requirements between the various applications disciplines. A common approach to meeting future data access and integration requirements, such as that proposed by the ADS, should improve the efficiency of individual projects while avoiding duplicate systems development efforts.

The objective of the Application Data Service (ADS) is to provide timely, affordable, accessible and readily usable multisource, multi-discipline data products to applications researchers and user government agencies.

Hence, the scope of the ADS objective includes catalogs and interfaces to all OSTA affiliated users and producers of data, including data dissemination and data services support to the mission agencies such as NOAA.

Services range from structured directories -- whose consultation can advise the users on the characteristics of available data -- where to find them, in what formats, how quickly, at what cost, whom to query; to providing services such as centralized accounting of moneys, budgetary estimates, logging of in-and-out data flows.

The ADS Plan is to meet future OSTA Data access and integration needs by building upon existing and planned Applications data systems. It will encourage the convergence of those systems and their products into a compatible and integrated structure, via a two-pronged approach:

- Definition of data and data systems standards
- Development of a network service for data transmission and integration.

The standards will provide guidelines for *future* programs: their definition and application will assure the natural evolution of future data and data systems compatibility. The network service, will streamline that systems efficiency. It will provide a single service to access data, provide required format conversions and integrate the cross-correlative data sets required by multiple users.

As to the networks, available technologies range from conventional mail through electronic delivery, with access at designated data archives and delivery to user terminals.

Services can range from structured directories whose consultation can advise the users on the characteristics of available data -- where to find the, in what formats, how quickly, at what cost, whom to query; to providing users with needed tools, such as gridding, overlays; and to supplying special services, such as centralized accounting of moneys, budgetary estimates, logging of in-and-out data flows.

Some users wish to receive data in their pristine form, and to perform their own manipulation: special services can provide the function of maintaining cognizance and delivering data-handling algorithms.

Other users desire data whose elaboration has progressed onto further stages: for these, special data services could supply central processing, e.g. geometric correction.

An important consideration, reflected in Section 16, is the eventual implementation of ADS by private commercial enterprise. Closely related thereto, also examined in Section 16, is the expected growth of technology, whose principal impact upon ADS is the reduction of costs and the increase of sophistication of data handling hardware and software foreseeable from such technological progress.

The technical problems facing the proposed Data Service are inherent in the current state and practice of the data storage and dissemination art. Six main characteristics of current methods will suffice to illustrate:

- Only a limited number of space data are available, and only from a few sources, in well-defined catalogued format and easily retrievable form;

- Most conventional data lie in widely dispersed repositories---no single, standardized directory is available as to their whereabouts, content, availability;

- Data exist in a variety of forms---analog, digital, imagery, tabulations, books, reports...

- Methods of data delivery vary among the data repositories---some insist on personal visits and on-the-spot copying, others react to telephone or mail inquiries, very few serve users by electronic methods;

- Deliveries, formats, freshness of data differ highly among repositories;

- Standards of data quality differ--no guide is extant to steer the searcher as to which data are generally reliable, which should be used circumspectly.

These design challenges will have to be coped with in future work phases. This report's purpose is to present the ADS technical drivers in organized perspective.

The report's structure is designed to answer the questions:

- What are the NASA OSTA uses

- What are the principal data problems driving the prformance of each use

- Who are the users of the data within the NASA research community

- What data characteristics do they perceive to be required

- What space-derived data exist now, what can be expected available in the 1980's, from what sensors and platforms, with what characteristics

- What auxiliary data are available, where, how to retrieve them

- What technical improvements and cost reductions can be expected to become available from the evolution of technology, and what is their foreseeable impact on ADS.

Methodology Employed and Structure of the Report

The material which follows presents a synthesis of the requirements by NASA users for OSTA space data and auxiliary data, through the next decade, 1980 to 1990.

Current requirements were derived from analysis of NASA plans and contributions by Discipline Scientists selected by NASA from within responsible Centers.

ECOsystems performed the functions of normalizing the diverse input formats into which the data were cast, reconciling eventual discrepancies, insuring the traceability of all items, and synthesizing the material into common, visible form. The resulting material was validated in three successive iterations by the Discipline Scientists and critiqued by Data Systems Planning Workshop participants.

The requirements of the near future were derived also from existing plans, and similarly validated. Because of its genealogy, the definition of "near future" is not firmly tied to a specific date: rather, it reflects the time span over which the source documents project future programs. Generally, with variations among disciplines this horizon extends from 1983 through 1985.

The further projection onto the 1985-1990 time frame was accomplished by extrapolating the various research activities from best available internal and external evidence. As an example of the former, some RTOP's project subsequent phases of their proposed program, even though no funding is available beyond the near term horizon. As an example of the latter, certain activities can reasonably be expected to convert into operational endeavors--to be performed by industrial users or other Federal Agencies. OSTA's corresponding R&D activities can be assumed to terminate on or about the projected date of such transition.

As in all projections, the accuracy of forecast diminishes as the time span recedes into the future. Nevertheless, the projections should reflect a reasonable structure of OSTA's program to the end of the coming decade when considered as a whole, barring of course significant breakthroughs or other radical redirections.

For example, it is not possible to foresee with exactitude whether a particular spacecraft's future new start will in effect become reality. It is however reasonable to assume that data missing through default of a particular mission will be compensated by data forthcoming from others.

Every effort was exerted to permit the reader of this report to trace the information herein contained to documented plans of NASA and other Federal Agencies involved in programs appertaining to the corresponding discipline.

In order to fit the stated user requirements into the corresponding programs, the selected approach required laying out an anticipated panorama of OSTA and related missions, and estimating the most probable characteristics of the data to be generated by the corresponding sensors.

A natural fallout of the approach was a census of the current user population.

Another effort censused the auxiliary data bases currently in existence within the Federal Government, and categorized them by their principal characteristics related to their potential usage by NASA users.

During the course of the effort, several queries were raised by Project personnel and by sundry interested Discipline Scientists as to the relationships and correlations between sets of data. To provide visibility from diverse interested viewpoints, the material, in addition to being presented in topic-related format, was also arranged to reflect the most significant correlations.

Detailed information on each of the above subjects is contained in the "Compendium of OSTA Space Data Usage Information" prepared by ECOsystems for the OSTA Data Systems Planning Workshop. This document summarizes this information, and presents the results of the analysis performed to extract therefrom the principal characteristics of an ADS serving NASA users.

As further reference for the interested reader, the above "Compendium" contains detailed description of user requirements, a Directory of space sensor characteristics and products, a Directory of

Space and Auxiliary Data Bases, matrices correlating Space Missions, Platforms, Sensors, Parameters.

3.1 Description of Objectives and Content

The Environmental Protection Agency (EPA) is the U. S. Federal agency responsible for monitoring, assessing and enforcing the purity of the atmosphere.

EPA's principal tactical goals are defined by the 1964 Clean Air Act and its subsequent amendments through 1977: "Abate and control air pollution systematically by proper integration of a variety of research, monitoring, standard setting and enforcement activities, and to serve as the public advocate for a livable environment."

Typical tactical concerns are with masses of polluted air which significantly impair visibility and give rise to acid rain or with the transport of oxidants, sulfates, nitrates and particulates which, in many locales, exceeds ambient air quality standards and results in impact on health.

EPA's strategic goal -- "to reinforce the efforts of federal agencies with respect to the impact of their operations upon the environment" -- is motivated by the concern that the introduction of anthropoygenic byproducts into the atmosphere may in the long run affect the earth's climate adversely, even catastrophically.

Early concern centered upon the potential effect of CO_2 in warming the atmosphere. Major study efforts are currently ongoing on the subject.

Beginning in 1971, concern expanded to include potential effects of other types of man-made products, notably exhaust emissions from high altitude aircraft and chloroflouromethanes. This concern is shared by HEW, DOE and DOT. The latter two agencies contribute significantly in fostering research activities.

Congress directed NASA in 1976 and 1977 to develop and implement a comprehensive program of research, technology, monitoring of the phenomena of the upper atmosphere, in participation with the scientific and engineering community and in support of cognizant federal agencies.

It turns out that the stratospheric processes are particularly sensitive to the injection of the aforesaid substances. For one, stratospheric ozone filters the sun's ultraviolet radiation, otherwise harmful to most forms of life. The photochemical processes that determine ozone formation, destruction and net balance are poorly understood. The increase in chemical content leading to new equilibrium values may alter this protective ozone barrier.

OSTA's Air Quality Discipline program supports EPA's tactical and strategic goals. Its objectives are to:

- Achieve understanding of large-scale dynamic and transport properties of the troposphere using space derived data and transfer the technologies developed to EPA.
- Achieve understanding of and assessment of man-made or natural threats to the upper atmosphere.

<u>Current OSTA Program</u>

OSTA's efforts comprising the Air Quality Discipline fall into four categories of R & D activities:

AQ 1 Assessment of the Atmosphere's Radiative Properties

Acquisition and evaluation of data bases to determine the role of ozone, aerosols and trace gases in the energy balance of the earth.

Its significance is that global measurements of ozone and other important atmospheric constituents, including aerosols, are needed for correlation with measurements of the earth's radiation budget to evaluate their impact on world climate.

AQ 2 Assessment of the Atmosphere's Chemistry

Development and test of models describing atmospheric chemical reaction rates for families of constituents, e.g., those containing nitrogen, hydrogen and chlorine, using remotely sensed distributions of source/sink molecular species.

Its significance is that understanding of the atmosphere's chemical processes is essential to develop methods for forecasting atmospheric chemical concentrations and for assessing the environmental and climatic impact of various human activities.

AQ 3 Assessment of Atmospheric Composition

Develop and test active and passive remote sensors for observing the distribution of atmospheric pollutants.

Significance is that advances in remote sensing technology, coupled with increased capability of analytical modeling, offers the best hope for significantly advancing local and global air quality assessment. Currently no adequate large scale pollutant distribution monitoring systems exist. This R & D Activity's efforts support joint EPA/NASA initiatives.

AQ 4 Assessment of Atmospheric Pollutant Transport and Dispersion

Development and test of models of pollutant transport and dispersion, to assist interpreting the meaning of atmospheric pollutant concentrations sensed from satellites.

Significance is that the transport of chemical constituents takes place in response to atmospheric motions on a variety of time and length scales. Understanding their mechanisms is essential to developing the capability to explain and predict pollutant concentrations.

Near Future OSTA Program

The program's philosophy is to demonstrate remote sensing techniques to observe atmospheric pollution and to understand the characteristics and distribution of tropospheric aerosols and pollutants.

The research elements of OSTA's near term Air Quality program are:

- The development of algorithms for reducing global CO measurements from the MAPS/OSTA-1 experiment.
- The application of HSRL to visibility measurements.
- The development of global tropospheric models for sulfur, ammonia, and aerosol systems.

An important technological element of OSTA's Air Quality program is the Upper Atmosphere Research Satellite (UARS) program, designed to provide a data base on the physics, chemistry and dynamics of the stratosphere -- to contribute to prediction and assessment of the effects thereupon of man-made perturbations.

Principal related technology development and utilization is in the following areas:

- Monitoring/detection of visible polluted air masses from aircraft and satellite data
- Continuation of the LAS measurement techniques for regional scale pollution episode
- The continued support of ground-based OH and CO measurements
- Aircraft measurement of stratospheric nitrogen and ozone, atmospheric gas constituents halocarbons, nitrous oxide and methane
- The development of data sets from NIMBUS-7 and SAGE (ozone)
- The continuation of the development of the data set for UV Solar Flux variability
- The extension of the global air quality monitoring program beyond NIMBUS and SAGE using a shuttle-borne high-speed interferometer
- The development of data sets from HALOE and Solar Mesosphere Explorer (SME) to determine the effect of incoming solar radiation ozone.

Future OSTA Program

The long range goals are to assess man's impact on the troposphere and the production and long range transport of oxidants and sulfates.

Key program plans are:

- Development of laser methods for detecting trace components OH and HO_2.

- Investigation of the role of non-methane hydrocarbons in the CO budget
- Assessment of the role of the stratosphere-troposphere exchange in the global ozone budget
- Determination of the global concentrations, sources and sinks of ammonia

Figure 3.1 presents a graphic synopsis of OSTA's Air Quality Program.

The first portion of the Figure reflects the space missions, current and projected, whose data products support the program. The subsequent portion and continuation sheet reflect the program's endeavors for each identified R & D Activity. Each element is referenced to its pertinent source documents; their titles are listed at the end of the Figure.

3.2 Relationships Between Data Services and the Air Quality Discipline

Figure 3.2 summarizes the requirements for space-derived data products expressed by the users.

Users are interested in obtaining parameters. These are intermediate information products derived from sensor measurements, elaborated via the application of appropriate algorithms. For example, atmospheric wind information derives from remotely sensed cloud motion data elaborated in conjunction with cloud top emissivity and radiance, atmospheric absorption, sensor calibration data.

At this time, NASA users in the Air Quality Discipline are in the process of developing such algorithms. For this purpose, they wish to

FIGURE 3.1

AIR QUALITY DISCIPLINE TIMELINE

OSTA MISSIONS

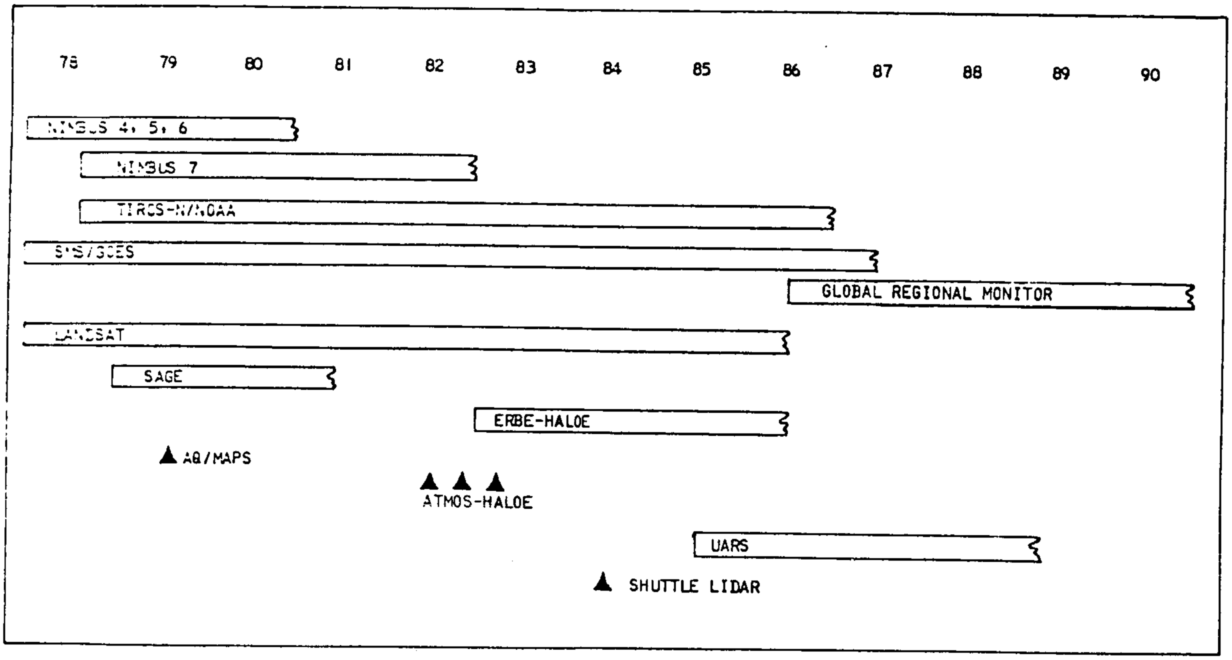
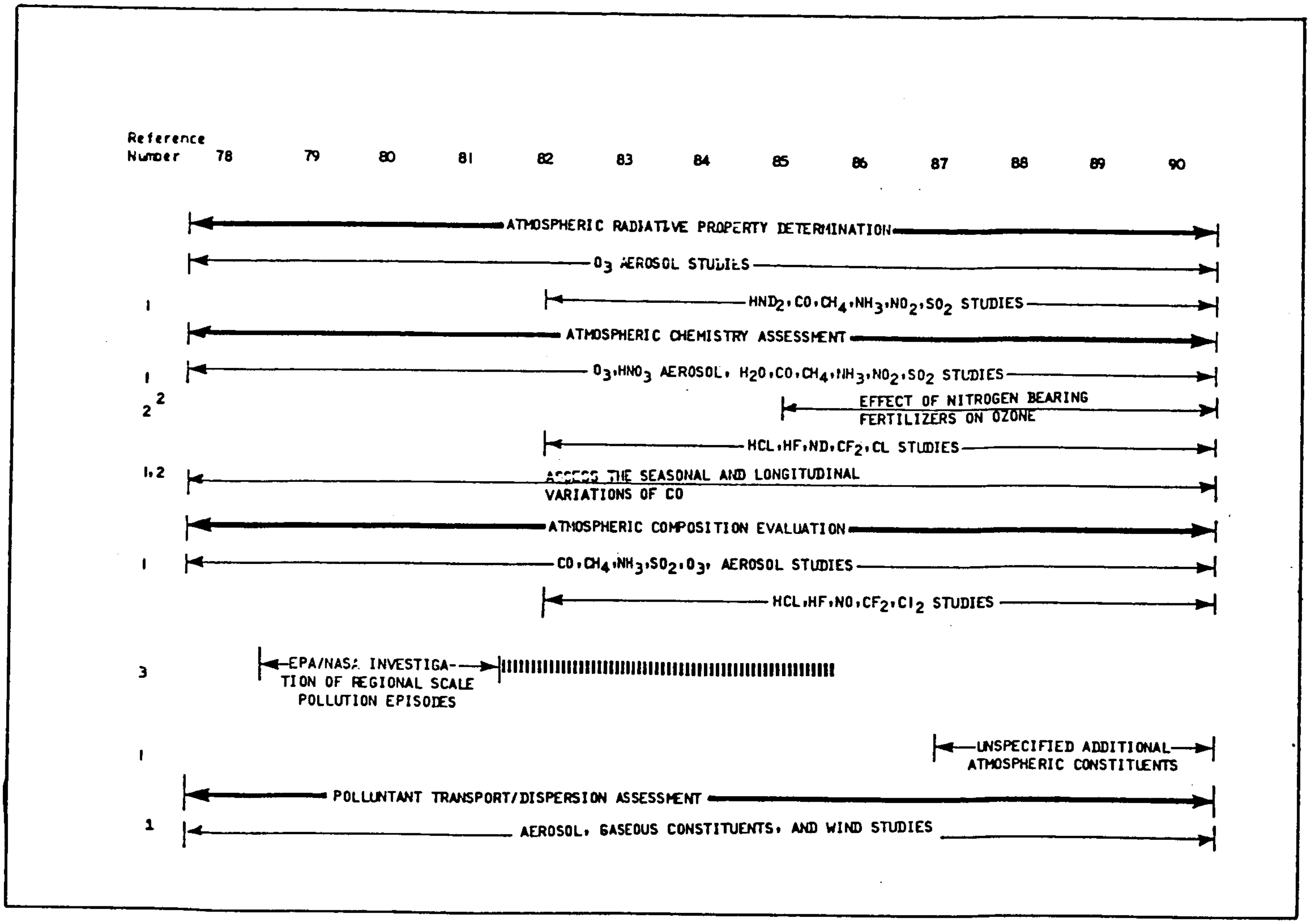


FIGURE 3.1 (cont'd)

AIR QUALITY DISCIPLINE TIMELINE

R & D ACTIVITIES



REFERENCES:
1) DATA PROVIDED BY DISCIPLINE SCIENTIST
2) ENVIRONMENTAL OBSERVATION DIVISION 5-YEAR PLAN FY 81-85 TO NASA PLANNING COUNCIL, 1979
3) PROJECT PLAN FOR COOPERATIVE INVESTIGATIONS OF REGIONAL SCALE POLLUTION EPISODES

LEGEND

1 Flight Mission
2 Program Emphasis
3 R&D Activity
4 Continuing Activity
5 Technology Transfer (Pilot/Application Tests Etc.)
6 Short Term Event
7 Initial Operational Capability
8 All Investigation Classes

FIGURE 3.2

USER REQUIREMENTS FOR SPACE DATA PRODUCTS, AIR QUALITY DISCIPLINE

		LANDSAT	NIMBUS 4	GOES	NIMBUS 7				AEM 2	TIROS N	SHUTTLE			ERBE/HALOE	UARS								SYSTEM 85	GLOBAL REGIONAL MONITOR								
		MSS	BUV	VISSR	SBUV/TOMS	LIMBS	SAMS	SAMS II	SAGE	TOVS	MAPS	ATMOS	LIDAR	HALOE	OR	CLI	ER	FIS	FR	MES	MLS	LHR	VISSR FOLLOW	OR-FOLLOW	CLIR-FOLLOW	ER-FOLLOW	FIS-FOLLOW	FR-FOLLOW	MES-FOLLOW	MLS-FOLLOW	LHR-FOLLOW	PRODUCT TOTALS
PARAMETERS																																
O_3 (OZONE)		●	●		●	●			●	●				●					●	●	●							●	●	●		
AEROSOLS								●	●	●	●		●												●							
HNO_3														●		●			●									●				
CO							●					●				●									●						●	
CH_4												●	●			●			●						●			●				
NH_3						●	●						●									●										
NO_2						●							●			●			●						●			●				
SO_2																																
H_2O												●	●			●			●			●			●			●			●	
HCL														●	●			●						●			●					
HF						●								●	●			●						●			●					
NO							●					●		●		●	●								●	●						
CF_2														●	●	●		●						●	●		●					
CL_2														●	●	●		●						●	●		●					
ATMOSPHERIC WINDS																					●		●							●		
DATA BANKS																																
NSSDC			●		●	●			●		●	●	●	●																		
GSFC/IPD					●	●				●																						
NOAA/NESS				●						●													●									
NCC/SDS																							●									
UARS/CDHF															●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	
EROS		●																														
PRODUCTS																																
1980	TAPES/YR.	-	150	-	150	110	20	10	140	20	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	630
	IMAGES/YR.	50	-	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100
	OTHER/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	G BITS/YR.	-	5	-	5	4	1.	0.4	5	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22
1985	TAPES/YR.	-	-	-	-	-	-	-	-	210	10	120	120	120	47	72	25	11	22	11	11	11	-	-	-	-	-	-	-	-	-	790
	IMAGES/YR.	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100
	OTHER/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	G BITS/YR.	-	-	-	-	-	-	-	-	7	0.4	8	4	4	2	3	1	0.4	1	0.4	0.4	0.4	-	-	-	-	-	-	-	-	-	28
1990	TAPES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	115	140	25	45	90	45	45	45	550
	IMAGES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-	-	-	-	100
	OTHER/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	G BITS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	5	0.1	2	3	2	2	2	19

receive raw space data, augmented by the auxiliary data summarized in Table 3.1.

The volume of required data is modest and sustained through the 1980 decade at approximately 25 Gigabits/year. The volume required of auxiliary data, from Table 3.1 is approximately one-third that of the space data.

From Figure 3.1 OSTA's program is essentially devoted to research efforts throughout the next decade, 1980-1990. Table 3.2 shows that the corresponding acceptable time lapse of data delivery is of order two to four weeks.

The investigation of regional scale pollution episodes, Figure 3.1, involves activities of technology transfer. These latter can acquire two forms: 1) algorithms and models developed by NASA researchers are tested on EPA-furnished facilities; or 2) they are tested on NASA facilities with participation by EPA personnel. The first form of transfer does not impact ADS because by current definition, ADS is intended to service NASA researchers only. In the second event, the timeliness requirements for data transfer would be of order of at least weekly, possibly daily.

Thus, during the 1980-1990 time frame, in which, and with possible exception of the aforesaid technology transfer activity, ADS data transfer requirements can be satisfied by a service of data rate comparable to that of the U.S. mail.

TABLE 3.1

USER REQUIREMENTS FOR AUXILIARY DATA PRODUCTS, AIR QUALITY DISCIPLINE

TYPE OF DATA	DATA PRODUCT FORMAT	SOURCE	ESTIMATED YEARLY PRODUCT VOLUME* AQ 1	AQ 2	AQ 3	AQ 4	TOTAL	USE OF DATA PRODUCT
Global Atmospheric Turbidity and Precipitation Chemistry Data	Digital Tape containing data for ~ 60 Global Stations	EDIS (NCC), EPA/ERC, NCAR, EPA/STORET	2	12	23	-	37	Verification of satellite air pollutant estimates
Ozone Soundings from Ballons	Digital Tape of Ozone Data Collected by Balloons Released from the 11 Station AFCRL Ozonsonde Network	EDIS (NCC)	4	24	23	-	51	Calibration and Verification of data from SBUV/TOMS, SAGE...
Solar Radiation Data	9 Track Digital (1600 BPI) Tape of hourly and daily solar radiation for U. S.	EDIS (NCC)	2	12	-	-	14	Calibration and verification of satellite solar radiation data from BUV, SBUV...
Daily Grid Analysis Data	Digital (800 BPI) Tape of gridded 10 level multisource wind, temperature and humidity analysis data	EDIS (NCC,NMC)	-	-	-	18	18	Correction and validation of VISSR derived winds for input to pollutant transport and dispersion models
Airborne Nephelometer	Computer printout of nephelometer measured aerosol scattering phase function	NCAR	-	12	23	18	53	Calibration and verification of SAGE aerosol concentration data
Rawinsonde Data	Digital Tape (800 BPI) of wind, temperature and humidity at 33 50 mb pressure heights	NCC	2	12	-	18	32	Correction and verification of satellite derived wind & temperature data for input to global tropospheric models
Airborne Interferometer and Spectrometer Data	Computer printout of wind temperature, NO_2 and multiconstituent data	NCAR WFC	-	12	23	-	35	Verification of satellite NO_2 and multiconstituent data

*Volume specified in number of individual products (Tapes, maps, reports....)

TABLE 3.2

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: AIR QUALITY (OBSERVATIONS)

	R & D ACTIVITY			
	ATMOSPHERIC RADIATIVE PROPERTY DETERMINATION	ATMOSPHERIC CHEMISTRY ASSESSMENT	ATMOSPHERIC COMPOSITION ASSESSMENT	POLLUTANT TRANSPORT/ DISPERSION ASSESSMENT
REQUIREMENTS	AQ 1	AQ 2	AQ 3	AQ 4
Horizontal Resolution (KM)				
Minimum	1	1	1	1
Maximum	500	500	500	500
Modal	1	1	1	1
Vertical Resolution (KM)				
Minimum	1	1	1	1
Maximum	5	5	5	5
Modal	1-5	5	5	5
Frequency				
Minimum	1 Day	1 Day	1 Day	1 Day
Maximum	1 Day	12 Hrs.	12 Hrs.	6 Hrs.
Modal	1 Day	1 Day	1 Day	1 Day
Data Delivery				
Research Investigations	4 Weeks	4 Weeks	4 Weeks	4 Weeks
Technology Transfer	4 Weeks	1 Week	1-2 Weeks	1 Week

TABLE 3.2 (Cont'd)

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THER USERS: AIR QUALITY

(SPECIAL SERVICES)

REQUIREMENTS	R & D ACTIVITY AQ 1	AQ 2	AQ 3	AQ 4
Reformat Satellite Data to one of several grids (50km, 200km, 500km)	X	X	X	X
Produce O_3 and Aerosol Concentration Maps	X			
Prepare Concentration Maps of Atmospheric Constituents	X	X		
Provide Multisource Data Sorting and Editing Service	X	X		
Provide Catalog & Dictionary Service for Satellite & Auxiliary Data	X	X	X	
Provide a Central Archive for A/C Sensor Data			X	
Form Multisource Data Sets for Evaluation of Remote Sensing Techniques			X	X

(STANDARD ALGORITHMS)

REQUIREMENTS	R & D ACTIVITY AQ 1	AQ 2	AQ 3	AQ 4
Atmospheric Radiative Properties:				
Albedo	X			
Absorbtion	X			
Transmittance	X			
Photochemical Models		X		
Dynamical Upper Atmospheric Models				X

This relatively slow data rate for ADS should not be confused with the essentially real time rates of data conveyance currently being planned for the UARS program. The reason is that these pertain to direct transfer of data from satellite to user, not from data archives to user. As such, this portion of UARS is essentially a self-contained entity, and does not impact ADS as currently defined.

The slow data delivery requirements do not necessarily connote that electronic linkages are not desirable. They simply indicate that the choice of the link is driven by economic cost-effectiveness rather than by technical urgency. For example, a plausible ADS scenario may well incorporate a centralized accounting, scheduling and data traffic monitoring facility; which maintains track of expenditures on the part of the users, supplies them budgetary estimates, advises them of impending depletion of project funds. Further analysis might reveal that such centralized management function can be performed more cost-effectively through use of electronic data links than through other conventional alternatives; quite apart from considerations of speed.

As a gross sizing of the "electronic link" alternative, the corresponding transfer requirements are such as to engage the equivalent of approximately 3 to 4 data links of 1,200 bps capacity each, operating on a one shift, normal work week basis.

Because the driver is economics, not technology, system tradeoffs can exploit to the fullest special tariff structures and price breaks: e.g., discounts for off-time operation, quantity savings from use of bulk bandwidths, use of satellite links whenever transfer distance exceeds the cost breakpoint (currently of order 900 kilometers).

Analysis of Table 3.3 leads to the inference that user services related to imagery manipulation -- e.g., geocoding, superposition of formats, gridding -- will impose significant technological requirements upon ADS. This is because relatively high spatial resolutions are required to satisfy the users, as per Table 3.3.

Users need to have available approximately 5 types of significant algorithms, Table 3.2, to be variously applied to derive each parameter. A potential evolutionary trend in the latter part of the 1980-1990 decade is the transition from user -- peculiar development of these algorithms to their routine use -- after the necessary confidence resulting from high "batting averages" will have been achieved.

Such evolutionary development would open the ADS to the opportunity of providing a centralized algorithm processing function. Algorithms which reach fruition would be transferred to this function for conventional processing: the researcher would retain the function of developing the newer generations of algorithms.

3.3 Implications of ADS on the Air Quality Discipline

Analysis of the requirements of the Air Quality Discipline users yields the following points:

- Approximately 80% of current users are involved in developing sensors and algorithms for the remote assessment of air pollution

TABLE 3.3

DATA SERVICE REQUIREMENTS FOR THE AIR QUALITY DISCIPLINE

		ATMOSPHERE RADIATIVE PROPERTY DETERMINATION	ATMOSPHERIC CHEMISTRY ASSESSMENT	ATMOSPHERIC COMPOSITION EVALUATION	POLLUTANT TRANSPORT DISPERSION ASSESSMENT
DATA LOCATION	Data Catalog	■	■	■	■
	Data Dictionary	■	■	■	■
	Computer Search	●	●	●	●
DATA EDITING	Quality Control				
	Data Sorting	●	●	●	●
REFORMATTING	Form Conversion				
	Code Conversion				
	Coordinate Conversion				
	Scale Conversion				
ASSEMBLY	Data Segment Preparation				
	Data Set Preparation	■	■	■	■
DATA INTEGRATION	Single-Source Multi-temporal Data Registration				●
	Single-Source Multi-temporal Data Merging				
	Multi-Source Uni-temporal Data Registration	●	●		●
	Multi-Source Uni temporal Data Merging		●		
	Data Gridding	●	●	●	●
	Data Overlay				●
	Image Mosaicing				
SPECIAL PROCESSING	Radiometric Correction	■	■	■	■
	Geometric Correction				
	Other				
DATA MGM'T	Data Archiving	1 ●	1 ●	1 ●	1 ●
	Data Delivery	2 ●	2 ●	2 ●	2 ●
		← FOR USE WITH UARS ONLY →			
OTHER					

■ High Value Data Service ● Desirable Data Service

Note 1: On Line

Note 2: Remote Interactive Smart Terminals parameters. These investigators generally provide their own data services. Incorporated into a general data service, these users do not typically engender speeded-up data delivery times and are relatively insensitive to product costs.

- Approximately 20% of current users are involved with developing the UARS program -- which includes MAPS, HALOE. By UARS's implementation time, approximately 1983-85, they will be provided rapid data delivery to accommodate the "smart terminal" on-line data system proposed for the program.
- The planned UARS data system represents in essence a self-contained "mini-ADS".
- Interaction between UARS researchers is desirable. An important service would be storage of data for at least 18 months, and provision for their near-real time availability.
- Users require central storage and retrieval of algorithms and atmospheric models and capability for interacting these with data bases on atmospheric circulation, e.g. NCAR.
- Current programs, e.g. MPAS and HALOE, require merging of significant quantities of auxiliary data. Reformatting and overlay services are desired.

ADS could provide valuable services to Air Quality Discipline users in the following aspects:

- Experience of other programs (e.g. LACIE Supersites, GISS) shows that data collected by individual investigators is generally valuable, but tends to dissipate with time. ADS could serve other interested NASA investigators by providing the service of collecting, centralizing, archiving and making available these data for retrieval, including the important function of providing uniform quality control.

- ADS could provide UARS data system with: a) optimization of procurement policies for "smart" terminals, of which 20 are planned. This would be particularly significant in view of both UARS's and ADS's potential expansion post-1985; b) standardization of data systems procedures and techniques. UARS could serve as a model for ADS, to be adapted to take into account the requirements of the other twelve OSTA Disciplines.
- Use of the UARS data system as a plug-in module to ADS, to provide interchange of data.
- Augmentation of UARS with the desired storage and retrieval capability for data and algorithms, and for interaction with other data bases, if not fully provided by UARS.

In summary, the principal impact of an ADS upon the users of the Air Quality Discipline would be reduction of time required to access data; and enhanced interaction capability with other OSTA Air Quality investigators.

The most significant functions of a data service to promote increased efficiency are:

- Establishment of an automated interactive data system to collect and archive user-peculiar instrument development data
- Standardization of data system procedures and techniques in order to accept UARS data systems outputs and to expand UARS automated data systems capability to other discipline data bases.

4.1 Description of Objectives and Content

NOAA is charged with structuring and directing the National Climate Program.

The Program's stated goals, established by Congress in 1977, are "to assist the nation to more effectively cope with climate-induced problems by enabling the forecast of climate fluctuations to assess domestic and international impact of climate fluctuations and to determine man's influence on the regional and global climate system."

The National Climate program includes three major areas of activity:

- Climate Impact Assessment
- Climate System Research
- Climate Data, Information and Services

Climate Impact Assessment involves identifying and quantifying how climate variations affect the ecosystem and society, measuring the resource attributes of climate, and developing response measures and strategies to cope with adverse climate variations. Its defined objectives are:

- Assess the biological and physical impacts of climate fluctuations that are significant to energy, environment, food production, water resources, and other areas of societal concern.

- Assess the socioeconomic implications of climate fluctuations and the consequences for response strategies and options.

- Develop and test measures for assessing the interactive impact of climate fluctuations, on land and water resources, socioeconomic and geophysical processes.

Climate Systems Research seeks to better understand the nature of climate processes and the mechanisms that produce variations of climate. Its objectives are to:

- improve knowledge of the temporal variations of global and regional climate.
- improve knowledge of the mechanisms responsible for climate variability.
- develop dynamical and statistical models capable of simulating climatic behavior.
- apply climate models to assess the sensitivity of climate to natural or anthropogenic perturbations.
- assess the predictability of climatic behavior and develop prediction tools.

Climate Data Information Services addresses four objectives:

- Observations: provide measures that establish an accurate and reliable record of the climate system's behavior.
- Data Management: assemble, provide quality control and archive climate data and ensure that appropiate data sets are available and accessible to users.
- Analysis and Projection: interpret past and present climate conditions; provide accurate, useful and timely information on current and future climates.
- Information Services: develop and deliver climate information to users having responsibilities in managing climate - sensitive sectors of the economy and government.

OSTA supports the National Climate Program with a related program of R&D activities. The objective of OSTA's Climate Discipline program is "to advance our practical understanding of the behavior of the climate system by concerted use of the global observational capabilities of space technology, of the data management and analysis capabilities of NASA and of the scientific community both without and within NASA.

The objectives of OSTA's Climate Discipline program are:

- Develop Climate Data Sets, e.g. precipitation over oceans, sea-ice concentration, ozone, radiation budget from the satellites observations
- Develop Models - varying degrees of complexity ranging from Global General Circulation Models (GCM) to 1-D Energy Balance Models for a variety of applications including investigations of climate processes, sensitivity studies to define boundary conditions upon which climate is dependent, simulations supporting design of the observing system and optimum sampling procedure. The emphasis of climate modeling is in testing the contribution of satellite data to the prediction of climate.
- Develop Remote Sensing Observation System. An earth radiation budget satellite system is planned. Also, improved techniques for observing sea surface temperatures, temperature profiles, wind profiles, precipitation, sea surface height, soil moisture, ice sheet thickness and motion.
- Perform Special Studies in six identified areas:

  aerosol effect, cloudiness and radiation budget, air/sea interactions, cryospheric processes, hydrologic processes (including precipitation, soil moisture and evapotranspiration), and sun/climate relationships.

Current OSTA Program

OSTA's efforts comprising the climate discipline fall into six categories of R&D Activities:

CL 1 Assessment of the Solar - Climate Coupling

Elements include:

= Evaluation and interpretation of the relationship between solar behavior and the cyclic behavior of climate as deduced from historical records.

= Measurement of solar brightness changes by improved measurement of the solar diameter.

= Investigation into the nature, cause, and magnitude of electrical coupling between the magnetosphere and middle atmosphere during auroral substorms, including the mapping of magnetospheric electrical fields.

The significance of this R&D Activity is that small variations in the sun's total or spectral radiant output can substantially affect weather and climate. Proper comprehension and description of such processes permits their incorporation in models used to forecast climate and weather, thereby improving prediction capability.

CL 2 Assessment of the Earth's Radiation Budget

Deduction of the atmosphere's radiative heating and cooling properties from remote measurements of chemical, trace and aerosol constituents.

Development of global cloud atlases to determine the relationship between cloudiness and the earth's radiation budget.

Location of atmospheric sources and sinks of energy in regions of climatic interest to determine empirical relationships between the energy budget and atmospheric dynamics.

This R&D Activity is significant because variations in the energy exchange between the earth-atmosphere system and space affect regional weather and evapotranspiration.

The zonal gradient of net radiation from equator to pole is an indicator of the amount of energy that must be transported by large-scale ocean and atmosphere circulations.

Clouds have a large effect on the radiation balance. Knowledge of the detailed relation of clouds to large-scale circulation and to radiative energy transfer is important to understand the impact of the circulation-cloud feedback loops on climate.

CL 3 Integrated Climate Modeling

Climate modeling activities seek to obtain quantitative understanding of climate processes, to support the development of space observing systems, and to develop techniques for effectively utilizing space-acquired data in climate analysis and prediction. These activities include the development of Statistical-Dynamical Models (SDM), the utilization of General Circulation Models (GCM) and the analysis of satellite and conventional climate data.

The models are used to:

= determine the sensitivity of climate to various atmosphere, land, ocean and cryosphere parameters and various time scales.

= perform simulations of potential observing systems.

= assess to what extent and on what time scales one can expect to forecast climate.

CL 4 Assessment of the Interaction between Cryosphere and Climate

This R&D Activity is related to the Cryosphere Discipline. The long term monitoring of global ice and snow deposits centers on developing and utilizing techniques of observation and data interpretation, quantitatively measuring parameters which determine energy exchange at the earth's surface (albedo, latent heat).

The key results will be the compilation of data sets of the extent of sea ice surface melting, and of ice accumulation patterns.

The significance of this R&D Activity is that the extent and duration of snow and ice cover are key variables in the earth's heat balance.

CL 5 Assessment of the Interaction between Land and Climate

This R&D Activity is related to the Water Resource discipline investigations of soil moisture and evapotranspiration.

Techniques for globally distributed measurements of soil moisture and evapotranspiration are being developed, based upon remote measurements of surface cover and especially adapted hydrologic models.

Their significance is that the flux of latent heat locked within water vapor from the surface to the atmosphere, and its subsequent release through condensation and precipitation, constitutes the largest single heat transfer mechanism within the atmosphere. Evapotranspiration patterns which vary due to changes in soil moisture, groundwater and vegetation are an important contribution to climate variability.

CL 6 Assessment of the Interaction between Ocean and Climate

Development of techniques for remotely measuring surface temperature, heat flux and rainfall over the oceans; and their use in global models to determine ocean-climate interactions.

The significance of this R&D Activity is that atmospheric and climatic data are obtained regularly over only 22% of the earth's surface. Only 2% of these observations are taken over the 71% of the earth's surface covered by oceans. Yet, ocean currents and related processes have important effects on weather and climate.

Near Future OSTA Program

The Program's philosophy recognizes the newness of the Climate discipline and the consequent need for sufficient time to arrive at significant results. As such, OSTA's near term program in the Climate discipline envisions essentially the continuation of the R&D Activities of the current program. A significant first fruit should be clearer understanding of the various facets of climate; e.g. Climate B, prediction; Climate C, basic knowledge; Climate X, impact of climate upon human activities.

The program's technological trend is the collection and integration of remotely sensed data from diverse available space platforms with possible focussing, later in the time frame, upon System 85, Icex, Thermosat space platforms.

Future OSTA Program

The long-term goal centers around the continued support of the National Climate Program. To this effect, OSTA's Program objectives are:

- Exploit to the greatest extent practicable instrumentation and data developed under NASA programs
- Build upon the expectation that the Global Weather Discipline program will have matured sufficiently to provide satellite remote sensing temperature profile, wind and pressure instrumentation and data;
- That the Ocean Processes Discipline program will have matured sufficiently to provide remotely sensed ocean temperature profiles, wind, pressure measurements, and microwave sea-surface temperature instrumentation and data;

- and that the Water Resources Discipline program will provide soil moisture instrumentation and data.
- Make available climate data sets to non-NASA users on an ad-hoc basis as they become available.
- Begin engaging in technology transfer activities of global mapping of aerosol and ozone profiles and regional climate predictions in the post-1985 time period.

Figure 4.1 presents a graphic synopsis of OSTA's Climate Discipline Program.

The first portion of the Figure reflects the space missions, current and projected, whose data products support the Program. The subsequent portion and continuation sheets reflect the Program's endeavors for each identified R&D Activity.

Each element is referenced to its pertinent source documents; their titles are listed at the end of the figure.

4.2 Relationships between Data Services and the Climate Discipline

Figure 4.2 summarizes the requirements for data products expressed by the users.

Users are interested in obtaining parameters. These are intermediate information products derived from sensor measurements, elaborated via the application of appropiate algorithms. For example, surface temperature information derives from remotely sensed radiance data elaborated in conjunction with surface emissivity, atmospheric absorption, sensor calibration data.

FIGURE 4.1

CLIMATE DISCIPLINE TIMELINE

OSTA MISSIONS

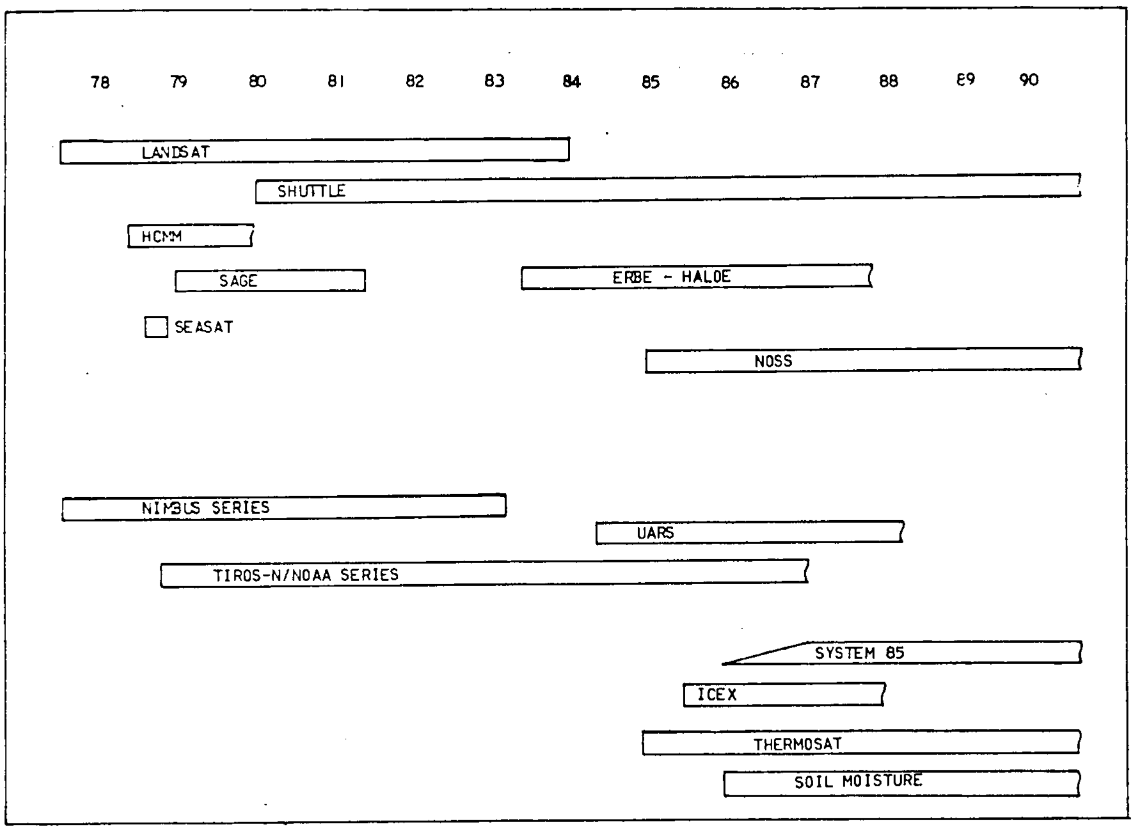
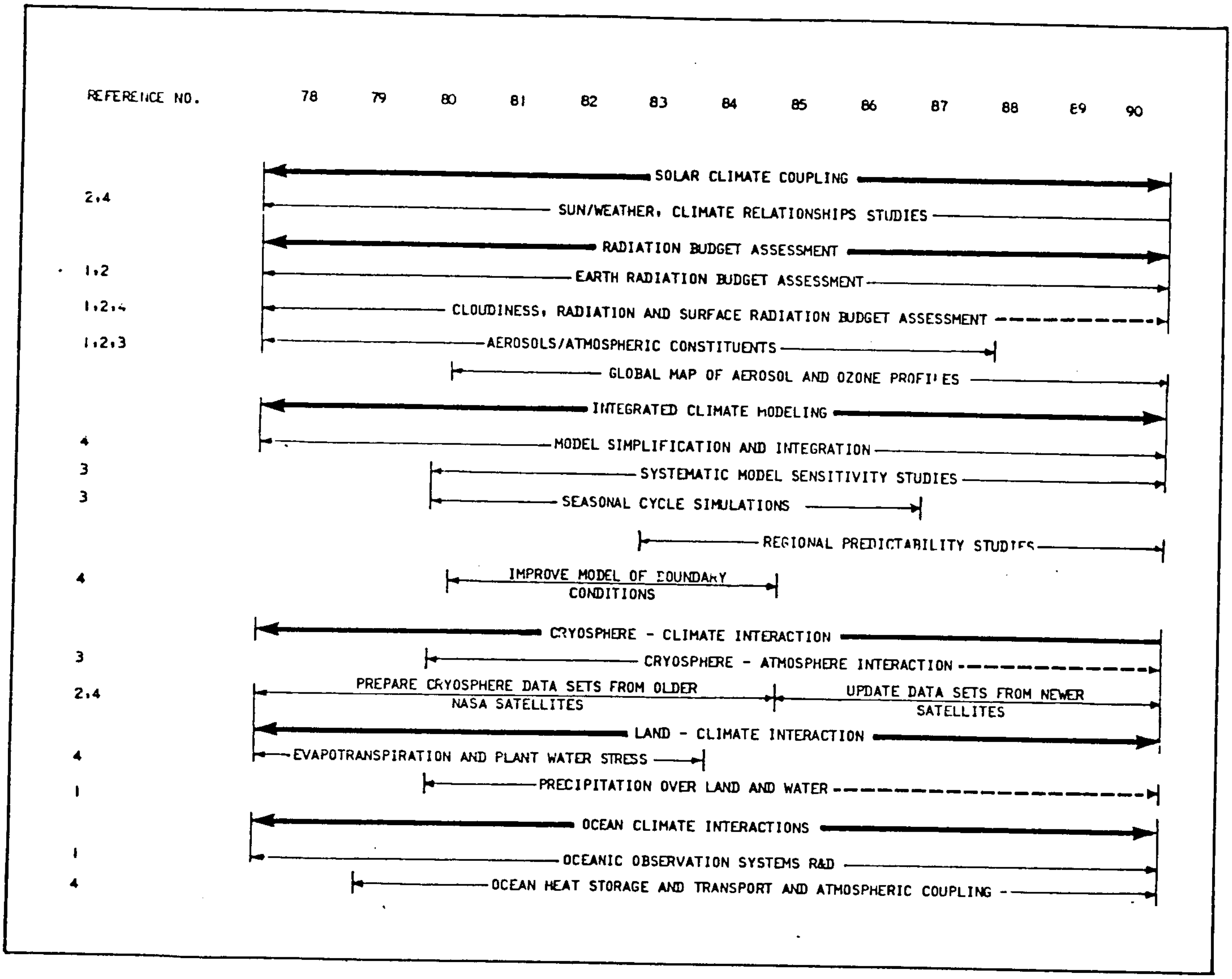


FIGURE 4.1 (cont'd)

CLIMATE DISCIPLINE TIMELINE
R & D ACTIVITIES



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LEGEND

1 Flight Mission
2 Program Emphasis
3 R&D Activity
4 Continuous Activity
5 Technology Transfer (Pilot/Application Tests Etc.)
6 Short Term Event
7 Initial Operational Capability
8 All Investigation Classes

FIGURE 4.2

USER REQUIREMENTS FOR SPACE DATA PRODUCTS, CLIMATE DISCIPLINE

	NOAA	GOES	LANDSAT	SEASAT				NIMBUS 5	NIMBUS 6		NIMBUS 7			AEM	HCMM	TIROS-N		SHUTTLE		UARS		
PARAMETERS	AVHRR	ALT	MSS	SMMR	SAR	SASS	ALT	ESMR	HIRS	ERB	SBUV/TOMS	ERB	SMMR	SAGE	HCMR	TOVS	AVHRR	SIR	ALT	MES	MLS	EFS
MEASUREMENT OF SOLAR CONSTANT										●		●										
MAGNETOSPHERIC ELECTRICAL FIELD																						●
OZONE CONCENTRATION											●			●		●				●	●	
ATMOSPHERIC ELECTRICAL PROPERTIES																						●
X-RAY PARTICLE DEPOSITION										●		●										
EARTH RADIATION BUDGET										●	●	●										
CLOUD COVER	●		●	●					●						●		●					
CLOUD LEVELS									●													
CLOUD THICKNESS																						
TROPOSPHERIC AEROSOLS														●								
STRATOSPHERIC AEROSOLS														●								
CLOUD PARTICLE ALBEDO																						
SEA SURFACE TEMP.	●			●				●					●		●		●					
SEA ICE CONCENTRATION	●		●	●				●					●		●		●	●				
SOIL MOISUTRE				●	●			●					●		●			●				
ICE/SNOW COVER	●		●	●				●					●		●		●	●				
AIR TEMP. PROFILES									●							●						
LAND SURFACE TEMP.	●			●				●					●		●	●	●					
HUMIDITY PROFILES				●					●				●			●						
OCEAN PRECIPITATION				●									●									
ICE/SNOW SURFACE TEMP.				●				●					●		●							
ICE/SNOW ALBEDO									●	●		●										
VEGETATION DENSITY			●												●							
OCEAN SURFACE WIND SPEEDS																						
SEA SURFACE ROUGHNESS						●	●												●			
DATA BANKS																						
NOAA/NESS	●															●	●					
NCC/SDS	●															●	●					
NSSDC		●						●	●	●	●	●	●	●	●			●	●			
GSFC/IPD								●														
EROS			●																			
JPL/SEASAT, CDHF				●	●	●	●															
UARS/CDHF																				●	●	●
PRODUCTS																						
1980 TAPES/YR.	114	8	100	140	420	420	420	140	60	150	30	150	374	42	120	90	644	-	-	-	-	-
1980 IMAGES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1980 OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1980 G BITS/YR.	4	0.3	4	5	15	15	15	5	2	5	1	5	13	1	4	1	23	-	-	-	-	-
1985 TAPES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	--	-	-	60	698	420	270	30	30	30
1985 IMAGES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1985 OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1985 G BITS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	24	15	7	1	1	1
1990 TAPES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1990 IMAGES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1990 OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1990 G BITS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

FIGURE 4.2

USER REQUIREMENTS FOR SPACE DATA PRODUCTS, CLIMATE DISCIPLINE (CONT'D)

	SMM	ERB/HALOE AEM		OERS	SOIL MOISTURE SAT	THERMOSAT	NOSS			SYSTEM 85	ICEX			SHUTTLE	ERB	GLOBAL REGIONAL MONITOR			
PARAMETERS	SCM	ERBE	HALOE	TM	MPMR	HCMR	LAMMR	ALT	SCAT	AVHRR-FOLLOW	IEAS	LAMMR	PIMR	ERSAR	ERBI	MES-FOLLOW	MLS-FOLLOW	EFS-FOLLOW	
MEASUREMENT OF SOLAR CONSTANT	●	●																	
MAGNETOSPHERIC ELECTRICAL FIELD																		●	
OZONE CONCENTRATION			●													●	●		
ATMOSPHERIC ELECTRICAL PROPERTIES																			
X-RAY PARTICLE DEPOSITION		●													●				
EARTH RADIATION BUDGET		●																	
CLOUD COVER				●		●				●									
CLOUD LEVELS																			
CLOUD THICKNESS													●						
TROPOSPHERIC AEROSOLS																			
STRATOSPHERIC AEROSOLS																			
CLOUD PARTICLE ALBEDO																			
SEA SURFACE TEMPERATURE						●	●			●		●							
SEA ICE CONCENTRATION				●	●	●	●			●		●	●	●					
SOIL MOISTURE					●	●	●					●		●					
ICE/SNOW COVER				●	●	●	●			●		●	●	●					
AIR TEMP. PROFILES																			
LAND SURFACE TEMP.						●	●			●		●							
HUMIDITY PROFILES							●					●							
OCEAN PRECIPITATION							●					●							
ICE/SNOW SURFACE TEMP.						●	●					●							
ICE/SNOW ALBEDO		●													●				
VEGETATION DENSITY				●		●													
OCEAN SURFACE WIND SPEEDS							●		●			●							
SEA SURFACE ROUGHNESS																			
DATA BANKS																			
NOAA/NESS																			
NCC/SDS										●									
NSSDC	●	●	●		●	●								●	●				
GSFC/IPD											●	●	●						
EROS				●															
NOSS/PPF							●	●	●										
UARS/CDHF														●		●	●	●	
PRODUCTS																			**PRODUCT TOTALS**
1980 TAPES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3362
1980 IMAGES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1980 OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1980 G BITS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	118
1985 TAPES/YR.	10	150	250	400	120	400	1206	218	420	240	-	-	-	-	-	-	-	-	4892
1985 IMAGES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1985 OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1985 G BITS/YR.	0.2	5	9	14	4	14	8	-	-	-	-	-	-	-	-	-	-	-	171
1990 TAPES/YR.	-	-	-	100	120	120	1273	420	420	1712	8	79	50	420	300	45	45	45	5157
1990 IMAGES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1990 OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1990 G BITS/YR.	-	-	-	4	4	4	45	15	15	60	0.3	3	2	15	11	2	2	2	181

At this time, NASA users in the Climate Discipline are in the process of developing such algorithms. For this purpose, they wish to receive raw space data, augmented by the auxiliary data summarized in Table 4.1.

The volume of required space data remains essentially constant through the 1980-1990 decade, approximately 120 Gigabits/year. The volume required of auxiliary data, from Table 4.1 is approximately one third that of the space data.

From Figure 4.1 OSTA's program is entirely devoted to research efforts throughout the 1980-1990 decade. Table 4.2 shows that the acceptable time lapse of data delivery is of order four weeks.

Thus, throughout the decade, ADS data transfer requirements can be satisfied by a service of data rate comparable to that of the U.S. mail.

The slow data delivery requirements of the early time frame do not necessarily connote that electronic linkages are not desirable. They simply indicate that the choice of the link is driven by economic cost-effectiveness rather than by technical urgency. For example, a plausible ADS scenario may well incorporate a centralized accounting, scheduling and data traffic monitoring facility; which maintains track of expenditures on the part of the users, supplies them budgetary estimates, advises them of impending depletion of project funds. Further analysis might reveal that such centralized management function can be performed more cost-effectively through use of electronic data links than through other conventional alternatives; quite apart from considerations of speed.

TABLE 4.1

USER REQUIREMENTS FOR AUXILIARY DATA PRODUCTS, CLIMATE DISCIPLINE

TYPE OF DATA	DATA PRODUCT FORMAT	SOURCE	ESTIMATED YEARLY PRODUCT VOLUME*							USE OF DATA PRODUCT
			CL 1	CL 2	CL 3	CL 4	CL 5	CL 6	TOTAL	
Surface Observations from WWW Synoptic Data Stations	Digital 800 BPI Tape of Wind, Air Temperature, Humidity, Air Pressure and precipitation, cloud cover and cloud base height data	EDIS (NCC, NMC)	36	252	108	-	24	-	420	Calibration & verification of data from HIRS, VTPR, VISSR, SMMR. Correlation with satellite data for 6 hourly inputs to multi-level meteorologic models such as the GLAS general circulation model.
Rawinsonde Observations	Digital 800 BPI Tape of Wind, Air Temperature and Humidity at 33, 50 mb pressure levels	EDIS (NCC)	3	21	9	-	-	-	33	Calibration & verification of satellite atmospheric sounder data. Correlation with satellite sounder data to improve vertical resolution for input to multilevel meteorologic model
Solar Radiation Data	9 Track Digital (1600 BPI) Tape of hourly and daily solar radiation for U.S.	EDIS (NCC, NGSDC)	3	21	9	-	-	-	33	Calibration and verification of satellite solar radiation data from BUV, SBUV ...
Ozone Soundings from Balloons	Digital (800 BPI) Tape of Ozone Data Collected by Balloons Released from the 11 Station AFCRL Ozonsonde Network	EDIS (NCC)	3	-	-	-	-	-	3	Calibration and verification of data from SBUV/TOMS, SAGE...
Airborne Nephelometer	Computer printout of nephelometer measured aerosol scattering phase function	NCAR	-	21	-	-	-	-	21	Calibration and verification of SAGE aerosol concentration data

*Volume specified in muber of individual products (Tapes, maps, reports..)

TABLE 4.1

USER REQUIREMENTS FOR AUXILIARY DATA PRODUCTS, CLIMATE DISCIPLINE (CONT.)

TYPE OF DATA	DATA PRODUCT FORMAT	SOURCE	ESTIMATED YEARLY PRODUCT VOLUME*							USE OF DATA PRODUCT
			CL 1	CL 2	CL 3	CL 4	CL 5	CL 6	TOTAL	
Synoptic Ocean Meterologic Observations	7 channel (556 BPI) digital tape of surface and upper air meteorologic data (wind, sea surface temperature, sea state air temperature, air pressure and humidity) for all available Northern hemisphere ship and fixed stations (≈9 days data per tape)	EDIS (NCC, NODC, NMC, NMFS)	30	210	90	40	-	50	420	Verification and calibration of satellite data for input to coupled ocean-atmosphere circulation models and ocean-cryosphere-atmosphere heat Flux sub models.
Drift Bottle Data	Low density (800 BPI) digital tape of surface and seabed current data	EDIS (NODC)	-	-	-	-	-	5	5	Verification of satellite-based ocean circulation model results
Data Buoy Data	Monthly digital (800 BPI) data buoy summary tapes of sea surface wind, air temperature and sea surface temperature, surface currents and wave spectra.	EDIS (NODC, NOAA/DBO)	-	-	27	-	-	15	42	Input to and verification of satellite based coupled ocean-atmosphere circulation models
Nansen Cast Data	High density digital tape (1600 BPI) to STD data down to 11,999 m	EDIS (NODC)	-	-	-	-	-	5	5	Calibration and verification of satellite based coupled ocean-atmosphere circulation models
Expendable Bathythermograph Data	Low density digital (800 BPI) Tape of ocean temperature data from 0 to 1850 m	EDIS (NODC)	-	-	9	-	-	5	14	Calibration of satellite based ocean-atmosphere heat Flux submodels
Surface Current Analysis Data	Monthly Fine Grid (1^ox 1^o) map of the average current down to the depth of the thermocline. Derived from the flow components based on the local temperature structure and modified for salinity effects and integrated wind stress.	EDIS (NODC)	-	-	27	-	-	5	32	Verification of results from satellite based coupled ocean-atmosphere circulation models

*Volume specified in number of individual products (Tapes, amps, reports....)

TABLE 4.2

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: CLIMATE (OBSERVATIONS)

	R & D ACTIVITY					
	SOLAR CLIMATE COUPLING	RADIATION BUDGET ASSESSMENT	INTEGRATED CLIMATE MODELING	CRYOSPHERE CLIMATE MODELING	LAND CLIMATE INTERACTION	OCEAN CLIMATE INTERACTION
REQUIREMENTS	C1	C2	C3	C4	C5	C6
Horizontal Resolution (KM)						
Minimum	0.1	5	1	0.05	200	200
Maximum	500	100	500	0.5	500	500
Modal	500	500	200-500	0.05-0.5	200-500	200-500
Vertical Resolution (KM)						
Minimum	N.A.	3	0.5	N.A.	N.A.	2
Maximum	N.A.	3	30	N.A.	N.A.	10
Modal	N.A.	3	1-10	N.A.	N.A.	1
Frequency						
Minimum	6-12 Months	1 Month	1 Week	1 Month	1 Month	1-5 Days
Maximum	1 Day	1 Week	1 Day	1 Week	1 Month	1 Day
Modal	1 Day	1 Month	1 Week	1 Month	1 Month	1 Day
Data Delivery						
Research Investigations	1-6 Months	1 Month	1 Month	1 Month	1 Month	1 Month
Technology Transfer	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

TABLE 4.2 (Cont'd)

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: CLIMATE (SPECIAL SERVICES)

	R & D ACTIVITY					
REQUIREMENTS	C1	C2	C3	C4	C5	C6
Locate Organize and Make Available Paleo-climatic Data in a Computer Compatible Form	X					
Collect & Maintain Correlary Auxiliary Data Sets for Inter-Agency and International Rocket Experiments	X					
Digitize and Map Auxiliary Data to Facilitate Analysis		X				
Produce Global Maps of Monthly Averaged Earth Radiation Budget with Uniform Spacial Resolution		X				
Maintain an Archive of A/C Sensor Test Tapes		X				
Reformat Satellite Data to Conform to Standard 46 X 72 and 72 X 120 Global Grid Cells			X			
Obtain and Archive Observational Data Sets of Identified Parameters for use in Evaluating the Ability of SDM and GCM Models to Simulate Climate Processes			X			
Cryosphere Related Observations in Gridded Registered, Spacially and Temporally Average Formats (Maps)				X		
Calibrate and Extract Cryosphere Related Parameters from Raw Satellite Data, and Archive & Distribute these Observations				X		
Digitize and Format Radar Data to Conform to SMMR Geographic Coordinates						X

TABLE 4.2 (cont'd)

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: CLIMATE

(STANDARD ALGORITHMS)

	R & D ACTIVITY					
REQUIREMENTS	C1	C2	C3	C4	C5	C6
Photochemical Models of the Upper Atmosphere	X					
Ozone Transport Models	X					
Atmospheric Energy Balance Models		X				
Radiative Transfer		X				
Cloud & Aerosol Volume Scattering Coefficients		X				
Spacial and Temporal Parameter Interpolation Schemes			X			
Surface Temperature Algorithms				X		
Snow/Ice Fraction Data Extraction Algorithms				X		
Evapotranspiration Algorithms					X	
Improved Boundary Layer Models					X	
Upper Ocean Heat Balance Models						X
Improved Ocean Circulation Models						X

As a gross sizing of the "electronic link" alternative during the "slow" R&D time frame, the corresponding transfer requirements are such as to engage the equivalent of approximately 16 data links of 1,200 bps capacity each, operating on a one shift, normal work week basis.

Because the driver is economics, not technology, system tradeoffs can exploit to the fullest special tariff structures and price breaks: e.g. discounts for off-time operation, quantity savings from use of bulk bandwidths, use of satellite links whenever transfer distance exceeds the cost breakpoint (currently of order 900 kilometers).

Analysis of Tables 4.2 and 4.3 permits the further inference that most user services related to imagery manipulation---e.g. geocoding, superposition of formats, gridding---will not impose significant technological requirements upon ADS. This is because relatively low spatial resolutions are adequate to satisfy the users. A notable exception is represented by R&D Activity "Cryosphere Climate Modeling," which however represents a relatively small portion of the total Climate Discipline Activity.

Much more stringent requirements apply to quality control of the data, and to the merging of scalar-vector types of data. This is because the achievement of meaningful results in Climate investigations requires high accuracy for all relevant data: the Climate researcher seeks to ascertain the presence of small deviations from long-term trends, e.g. fractions of a degree steady temperature drop over a decade.

TABLE 4.3

DATA SERVICE REQUIREMENTS FOR THE CLIMATE DISCIPLINE

		SOLAR-CLIMATE COUPLING	EARTH RADIATION BUDGET ASSESSMENT	INTEGRATED CLIMATE MODELING	CRYOSPHERE CLIMATE INTERACTION	LAND-CLIMATE INTERACTION	OCEAN-CLIMATE INTERACTION
DATA LOCATION	Data Catalog	■	■	■	■	■	■
	Data Dictionary	■	■	■	■	■	■
	Computer Search			●			●
DATA EDITING	Quality Control						●
	Data Sorting	●	●			●	●
REFOR MATTING	Form Conversion						
	Code Conversion						
	Coordinate Conversion						●
	Scale Conversion						
ASSEMBLY	Data Segment Preparation	●				●	
	Data Set Preparation	■	■	■		■	■
DATA INTEGRATION	Single-Source Multi-temporal Data Registration		●		●		●
	Single-Source Multi-temporal Data Merging	●					
	Multi-Source Uni-temporal Data Regis-tration	●					●
	Multi-Source Uni temporal Data Merging			●	●		
	Data Gridding	●	●	●	●	●	●
	Data Overlay	●	●			●	
	Image Mosaicing						
SPECIAL PROCESSING	Radiometric Correction			●			
	Geometric Correction			●			
	Other						
DATA MGM'T	Data Archiving	■	■	■	■	■	■
	Data Delivery						
OTHER		● 1	● 2		● 3	● 4	● 5

■ High Value Data Service ● Desirable Data Service

Note 1: Prepare Data Summaries of Solar Constant
2: Prepare Data Summaries of Cloud Cover Distributions and Radiation
3: Prepare Data Summaries of Monthly Snow/Ice Cover
4: Prepare Data Summaries of Seasonal Soil Moisture Changes
5: Prepare Summaries of Ocean Rain Fall, Surface Temp, Winds

Users need to have available in excess of 20 significant algorithms, Table 4.2. A potential evolutionary trend in the latter part of the 1980-1990 decade is the transition from user-peculiar development of these algorithms to their routine use--after the necessary confidence resulting from high "batting averages" will have been achieved.

Such an evolutionary development would open the ADS to the opportunity of providing a centralized algorithm processing function. Algorithms which reach fruition would be transferred to this function for conventional processing: the Researcher would retain the function of developing the newer generations of algorithms.

4.3 Implications of ADS on the Climate Discipline

The Atmosphere Panel at the Data Systems Planning Workshop concluded that:

- Current archives of Climate data on magnetic storage media (CCT) are deficient: data sets are incomplete and need better quality control
- Budget initiatives planned by NOAA (EDIS) for FY82 to correct deficiencies should bear fruition approximately in 1986
- NOAA (NCC) is procuring a mass storage facility, and is developing a data base management system accessible by remote terminals to be ready by late 1985
- Procurement is underway at NOAA for a full-resolution GOES mass storage data archiving system
- An inventory system for NOAA satellite data, accessible from remote terminals is scheduled to be on line in 1985. NASA

accessing could possibly begin as early as 1983. Data transmission of large quantities of data over communication lines is not planned - mail delivery of tapes is contemplated due to transmission costs.

The results of the analysis of the user requirements for the Climate Discipline are:

- Rapid data delivery is generally not a critical requirement. The provision of mail delivery of copies of CCT will suffice for the large majority of users. A provision for on-line data access should also be made available for experiments with interactive auxiliary data requirements.

- The data base for Climate studies is jointly divided between NASA and NOAA. Many researchers indicate that the time and expense required for digesting the large number of tapes involved in constructing data sets limits their performance.

- Users generally agree that a climate data catalog service is essential. Its concept should be flexible to allow inclusion of externally generated pedigree and use information. At least a three level hierarchy structure is required.

- The highest level should include brief data identification, content summary, potential applications.

- The second level should contain all information important to users of the data: either via a quick-look capability or at least through samples of the data product, probably in graphical form. Key information to be included are: data characteristics; data limitations; indices to pertinent data experts; supporting computer programs and documentation; directories to specific data; format descriptions.

- The third catalog level should include supporting data set documentation essential for most data uses.

- Development and testing of Climate models for predicting monthly, seasonal and interannual, climate variability generally requires the availability of numerous data sets.

  Due to the cost involved, users typically spend considerable time in preselecting, editing and summarizing the data sets prior to acquisition. Climate users indicated the need for an interactive data system to both reduce the time involved in building comprehensive Climate data sets and the costs of data acquisition.

In summary, the principal impact of an ADS upon the users of the Climate Discipline would be economic, i.e. significant reduction in the time and cost involved in building comprehensive climate data sets.

Two functions would be paramount in promoting increased efficiency:

- A comprehensive data catalog to assist users in data selection and location, both for primary and auxiliary data sets. Key features of the catalog would include data pedigree.

- Establishment of an automated interactive system to assist users in previewing, editing and summarizing climate data sets.

5.1 Description of Objectives and Content

New U. S. responsibilities within the coastal zone have resulted from recently enacted public law, international treaties, executive orders, and regulations which require government management of vastly increased offshore areas and impose an increased number of tasks upon agencies responsible for coastal zone management.

The U. S. Coast Guard (USCG) is charged with:

- Patrolling the new 200 nmi coastal zone
- Patrolling large international fisheries areas
- Regulation of oil tanker navigation (pending legislation)
- Protection of marine mammals (porpoise, whales)

NOAA's National Ocean Survey charts U. S. coastal and Great Lakes waters, monitors and predicts tides and tidal currents, tests new oceanographic sensors and is developing a system of automated ocean data buoys. NOAA's Environmental Research Laboratories conduct programs aimed at improving our understanding of the physical proccesses and mineral resources of the marine environment. The National Marine Fisheries Service conducts broad research and service programs aimed at improving our comprehension and use of ocean's living resources. The National Weather Service provides a wide variety of marine and oceanographic reports and forecasts and transmits timely warnings of natural hazards. The Environmental Data Service manages and processes the world's largest collection of marine environmental data. The National Environmental Satellite Service is developing ways to monitor events in the global ocean from the vantage point of space.

The Office of Sea Grant provides assistance to educational institutions and states, principally for research and advisory services to aid in planning marine activities. The Office of Coastal Environment acts as a focal point for aiding government, the public, industry, universities, and other institutions in their efforts at coastal zone management.

The major thrust of the OSTA Coastal Zone Discipline program is the development of space technology to meet the present and future coastal zone monitoring requirements of federal agencies. The OSTA Coastal Zone Discipline program also plays an active role in assisting state agencies to enhance their capability to monitor and manage the portions of the Coastal Zone Management Act which authorize the use of technical and financial federal resources to encourage and assist states in the development and operation of comprehensive coastal zone management programs.

Current OSTA Program

The OSTA efforts within the Coastal Zone Discipline are related to five categories of R & D activities:

CZ 1 Wind/Wave Interactions

Measurement techniques and algorithms are being developed to assess the transfer of momentum between the atmosphere and the ocean in the near shore regions.

Wind shear drives the ocean surface layer motion which move fish larva and oil spills, cause storm tides and subsequent upwelling in the coastal areas. An understanding of wind-wave interaction is also important to ship routing, ship operations scheduling, ship design, resource exploration, sea state and current forecasts, iceberg forecasts, resource and pollution management which are treated in the Ocean Processes and Cryosphere Disciplines.

CZ 2 Coastal and Estuary Circulation

Measurement techniques and algorithms are being developed to assess coastal circulation patterns due to tides, fresh water influx, land surface runoff, geostrophic currents and underwater springs.

Knowledge of the circulation patterns is important to coastline erosion management and to assessing and forecasting coastal marine resources and fisheries yields, and to provide increased understanding of the potential impact of pollutant transport and dispersion processes in the coastal zone. Coastal and estuarine circulation patterns also depend upon the Coastal wind/wave interaction investigations.

CZ 3 Coastal Thermal Balance

Measurement techniques and algorithms are being developed to estimate thermal transport in the coastal zone area; including thermal and water exchange with the atmosphere and with human activities such as power plant thermal plumes.

The results of these investigations provide important inputs into regional and local weather and climate forecasting models. In addition, the thermal balance effects biological production and pollutant impacts on biological growth.

CZ 4 Coastal Biology and Chemistry

Measurement techniques and algorithms are being developed to assess coastal ocean biological and chemical processes.

Biological growth patterns are important in locating and maintaining marine fish and aquaculture resources. Chemical pollutants affect this biological balance and their transport and dissipation is important.

CZ 5 Coastal Bottom Topography

Measurement techniques and algorithms are being developed to measure coastline bottom topography, shoreline changes, and sediment transport.

Changing coastal shorelines and bottom topography affect navigation, drilling rig foundation stability, beach maintenance feasibility, and harbor shoreline erosion.

Near Future OSTA Program

The near future goal of the Coastal Zone Discipline Program is investigation of advanced monitoring techniques applicable to near and long-term coastal zone monitoring problems.

The program incorporates aircraft and in-situ research with the emphasis on coastal and estuary circulation and biological processes. Some space demonstrations, based primarily on Nimbus 7, are also planned.

The research elements of OSTA's near term Coastal Zone Program are:

- Comparison of airborne SAR measurements with in-situ wind/wave measurements.
- Development of sea state forecast models

- Development of sea surface temperature profile models based on surface temperature measurements

An important technology element of the coastal zone program is the possible definition of a dedicated coastal zone satellite COASTSAT as a follow-on to NOSS measurements. Principal related technology and utilization is in the following areas:

- Sea State technology demonstrations
- Laser/Altimeter coastal bottom topographic measurements

Future OSTA Program

The goals of future OSTA's Coastal Zone Discipline are to:

- Conduct investigations into the status of coastal zone management and monitoring and identify areas of necessary and desirable improvements, including the analysis of the legal and regulatory requirements for coastal zone and treaty fisheries areas in coordination with responsible agencies.
- Examine advanced space and non-space technology for application to coastal zone monitoring. Particular emphasis will be placed upon investigating advance space technology for monitoring. Advanced technologies in related areas such as ground data network and surface/air monitoring may also be considered.
- Determine the potential benefits to be derived from implementation of space systems. Cost estimates will be made for satellite-based monitoring systems and compared with costs of other techniques. Intangible benefits such as marine life protection and lifesaving potential will also be assessed.

- Develop satellite systems and techniques for coastal zone monitoring. Advanced satellite monitoring systems will be developed to provide effective monitoring tools for user agencies through the use of technology specifically designed to meet the requirements of these agencies.

In the 1985+ period a broader range of exploratory and in-situ research is envisioned as existing data is applied to more applications and new aircraft remote sensors are developed and tested. The 1985 Coastal Zone program is directly derivable from the present coastal-ocean and coastal-zone-management program plans and the published terrestrial applications mission scenario. The key feature of Coastal Zone Discipline program for the 1985+ time is the use of NOSS and Shuttle pallet missions for space demonstrations.

In the 1985+ time period, the program assumes that the sensors currently under demonstration in aircraft will become sufficiently mature to be considered for inclusion in operational or research space flights. Improved spatial resolution is the key to many coastal and estuary problems and a wide range of spectral diversity is needed to detect the variety of biological and chemical parameters of interest. A second generation NOSS with improved areal resolution capability or a COASTSAT mission with the finer area resolution and an orbit optimized for coastal coverage is expected to provide the observational support required by the Coastal Zone Discipline in the 1985-1990 time frame.

Figure 5.1 presents a graphic synopsis of OSTA's Coastal Zone Program.

The first portion of the Figure reflects the space missions, current and projected, whose data products support the Program. The subsequent portion and continuation sheet reflects the Program's endeavors for each identified R&D Activity.

Each element is referenced to its pertinent source documents; their titles are listed at the Figure's end.

5.2 Relationships between Data Services and the Coastal Zone Discipline

Figure 5.2 summarizes the requirements for data products expressed by the users.

Users are interested in obtaining parameters. These are intermediate information products derived from sensor measurements, elaborated via the application of appropriate algorithms. For example, surface water temperature information derives from remotely sensed radiance data elaborated in conjunction with surface emissivity, atmospheric absorption, sensor calibration data.

At this time, NASA users in the Coastal Zone Discipline are in the process of developing such algorithms. For this purpose, they wish to receive raw space data, augmented by the auxiliary data summarized in Table 5.1.

FIGURE 5.1

COASTAL ZONE DISCIPLINE TIMELINE

OSTA MISSIONS

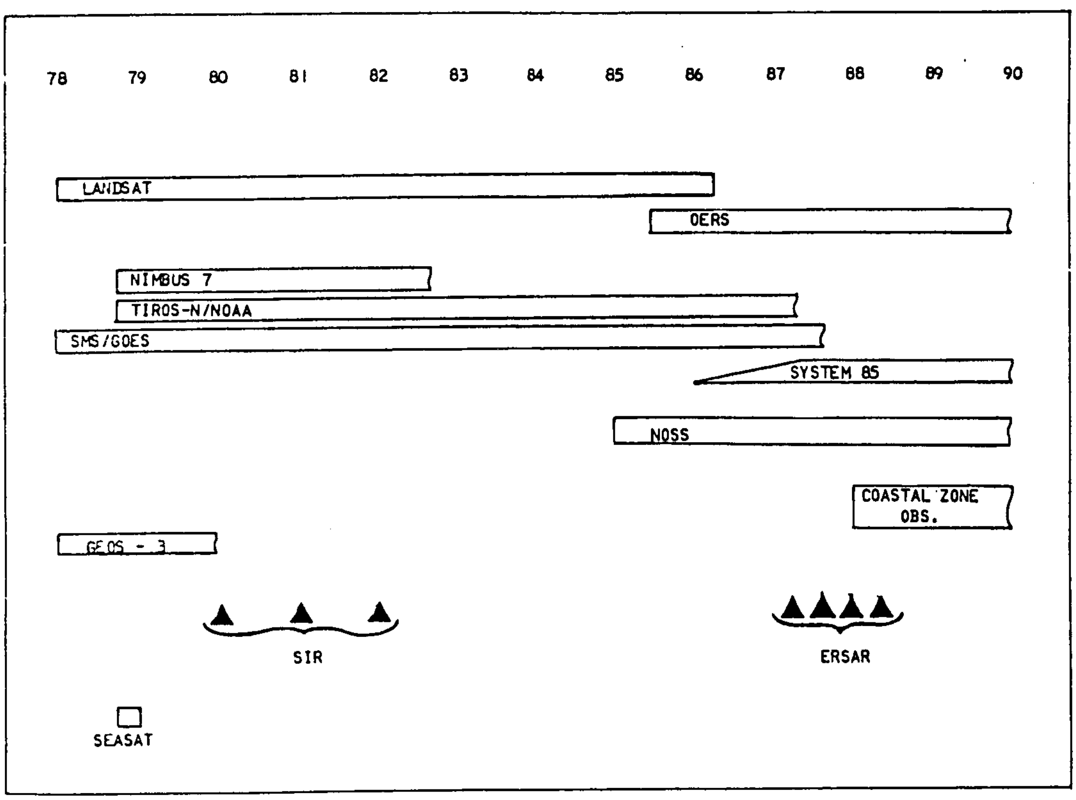
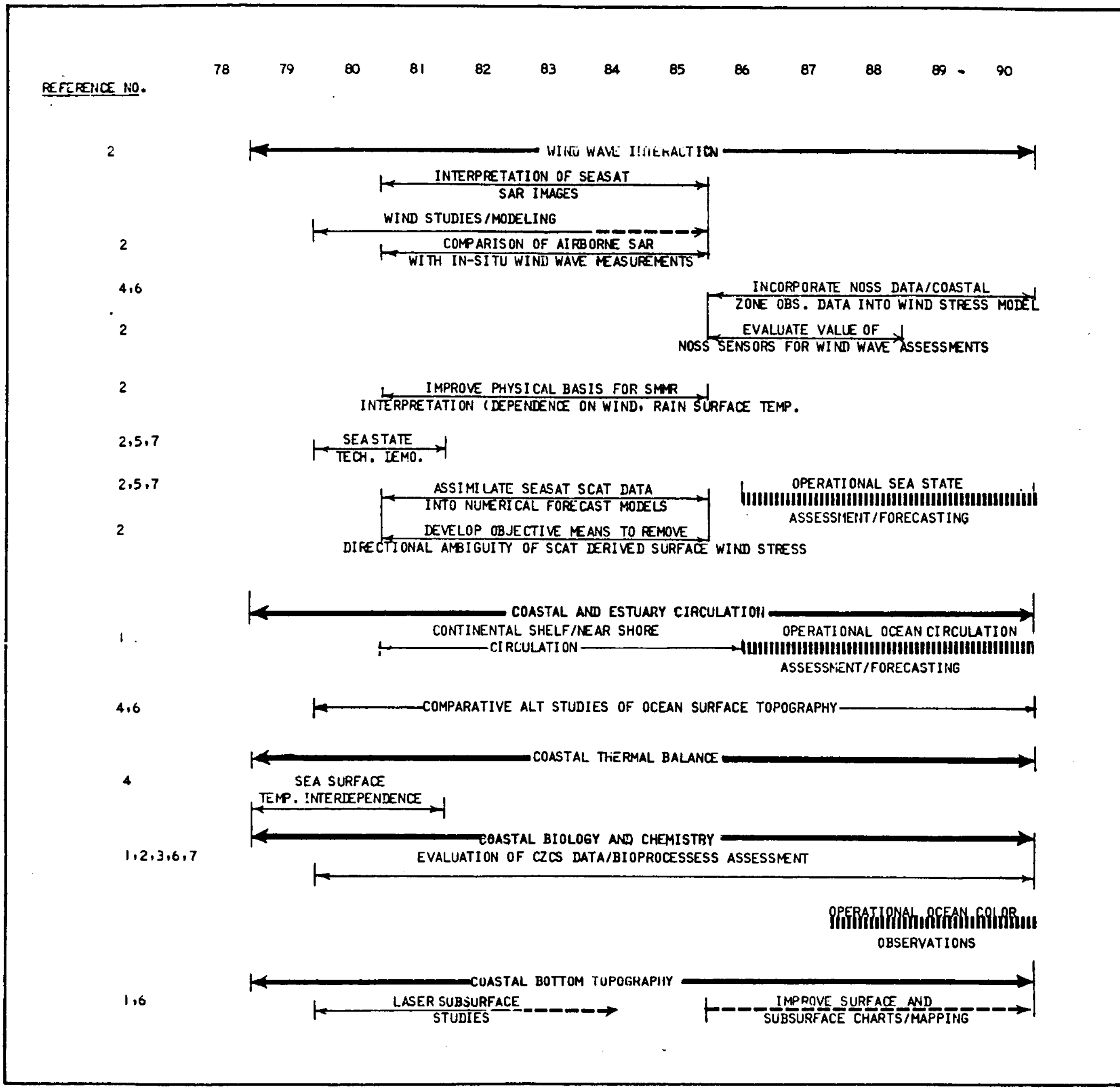


FIGURE 5.1 (Cont'd)

COASTAL ZONE DISCIPLINE TIMELINE

R & D ACTIVITIES



REFERENCES:

1) NASA 5 YEAR PLANNING FY80 THROUGH 1984, 1979
2) ENVIRONMENTAL OBSERVATIONS DIVISION 5 YEAR PLAN: FY 80-85 TO NASA PLANNING COUNCIL
3) RESOURCE OBSERVATION 5 YEAR PLAN PRESENTATION TO NASA PLANNING COUNCIL
4) ENVIRONMENTAL OBSERVATION REPORT 10 YEAR PLAN, 1979
5) ASVTS
6) RTOPS
7) ANS

LEGEND

1 Flight Mission
2 Program Emphasis
3 R&D Activity
4 Continuing Activity
5 Technology Transfer (Pilot/Application Tests Etc.)
6 Short Term Event
7 Initial Operational Capability
8 All Investigation Classes

FIGURE 5.2

USER REQUIREMENTS FOR SPACE DATA PRODUCTS, COASTAL ZONE DISCIPLINE

		GEOS 3	DMSP BLOCK 5	SEASAT A					NIMBUS 7		SMS GOES	TIROS N	LANDSAT		SHUTTLE	DMSP BLOCK 6	NOSS				SYSTEM 85		SHUTTLE	OERS	TOPEX	COASTSAT	
PARAMETERS		ALT	OLS	SMMR	SASS	SAR	VIR	ALT	SMMR	CZCS	VISSR	AVHRR	MSS	TM	SIR	OLS	LAMMR	SCAT	CZCS	ALT	AVHRR-FOLLOW	VISSR-FOLLOW	ERSAR	TM	ALT	COLORI-METER	
WAVE HEIGHT		●						●												●							
WAVE LENGTH*						●									●								●				
WAVE DIRECTION						●									●								●				
SEA SURFACE ROUGHNESS					●													●									
SEA SURFACE WIND SPEEDS				●	●				●								●										
WATER COLOR (MULTISPECTRAL REFLECTANCE)										●			●	●					●					●		●	
SURFACE WATER TEMPERATURE			●	●			●		●		●	●				●	●				●	●					
WATER SURFACE HEIGHT		●						●												●							
SURFACE AIR TEMPERATURE			●	●					●							●	●										
COASTAL CIRCULATION*		●			●			●										●		●					●		
SURFACE SALINITY										●									●					●		●	
CHLOROPHYLL										●									●					●		●	
NUTRIENTS										●									●					●		●	
DATA BANKS																											
NSSDC		●							●	●					●								●		●	●	
GSFC/IPD									●	●																	
NOAA/NESS				●	●	●	●	●			●	●									●	●					
JPL/SEASAT CDHF				●	●	●	●	●																			
NOSS/PPF																	●	●	●	●							
NCC/SDS											●	●									●	●					
EROS													●	●	●								●				
DMSP/SATELLITE DATA LIBRARY			●													●								●			
PRODUCTS																											**PRODUCT TOTALS**
1980	TAPES/YR.	108	32	910	168	1446	56	108	90	282	120	240	102	20	-	-	-	-	-	-	-	-	-	-	-	-	2856
	IMAGES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OTHERS/YR.	-	-	-	-	360FS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	360FS
	G BITS/YR.	4	1	3	6	50	2	4	3	10	4	8	4	0.7	-	-	-	-	-	-	-	-	-	-	-	-	100
1985	TAPES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	32	12	18	24	12	72	4	70	40	-	-	-	-	304
	IMAGES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	40FS	-	-	-	-	-	-	-	-	-	-	-	40FS
	G BITS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	1	0.4	0.6	0.8	0.4	3	0.8	2	1	-	-	-	-	11
1990	TAPES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24	12	80	54	163	46	22	122	6	202	731
	IMAGES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	60FS	-	-	-	60FS
	G BITS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.4	3	2	6	2	1	4	0.2	7	26

TABLE 5.1

USER REQUIREMENTS FOR AUXILIARY DATA PRODUCTS, COASTAL ZONE DISCIPLINE

TYPE OF DATA	DATA PRODUCT FORMAT	SOURCE	ESTIMATED YEARLY PRODUCT VOLUME*						USE OF DATA PRODUCT
			CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	TOTAL	
Data Buoy	Monthly regional digital (800 BPI) data buoy summary tape of sea surface wind, air temperature and sea surface temperature, surface currents and wave spectra	EDIS (NODC)	14	4	4	4	-	26	Correction and verification of oceanographic data derived from SASS, SMMR, ALT...
Nansen Cast Data	Digital (1600 BPI) tape of STD data down to 11,999 m	EDIS (NODC)	-	4	4	4	-	12	Correction and extrapolation of satellite sea surface temperatures and salinity estimates for input to thermohaline circulation models
Expendible Bathythermograph Data	Low density digital (800 BPI) tape of water temperature profile data (0 to 1830 m)	EDIS (NODC)	-	4	4	4	-	12	Verification of satellite derived coastal and estuary thermal structure data and thermal corrections to satellite derived circulation patterns
Synoptic Ocean Meteorologic Observations	7 channel (556 BPI) digital tape of surface and upper air data (wind, sea state, sea surface temperature, surface air pressure, and air humidity) from coastal land, ship and fixed ocean stations in the northern hemisphere. (~9 days data per tape)	EDIS (NCC, NODC, NMC, NMFS)	56	16	16	16	-	102	Verification of satellite derived sea state, sea surface wind speeds and temperatures. Calibration of satellite data for input to coupled atmosphere-ocean circulation models
Bathemetry Data	1:10,000 scale and estuary bathemetry map derived from ship and aircraft sounding surveys.	EDIS (NODC)	14	20	-	-	5	39	Verification of bathemetry results derived from satellite ocean and estuary color observations. Correction of satellite derived circulation results for bottom topography effects.

*Volume specified in number of individual products (Tapes, maps, reports....)

TABLE 5.1

USER REQUIREMENTS FOR AUXILIARY DATA PRODUCTS, COASTAL ZONE DISCIPLINE (CONT.)

TYPE OF DATA	DATA PRODUCT FORMAT	SOURCE	ESTIMATED YEARLY PRODUCT VOLUME*						USE OF DATA PRODUCT
			CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	TOTAL	
Drift Bottle Data	Digital (800 BPI) tape of surface and seabed current data	EDIS (NODC)	14	4	-	-	-	18	Verification of satellite ocean circulation model results
Marine Biology and Chemistry Data	Microfilmed, cruise record includes data such as water sample and plankton net analysis results (available by cruise, area and time sort)	EDIS (NODC) SCRIPPS WHOI NMFS	-	-	-	5	-	5	Correlation with water color for derivation of biological and pollutant specie distributions

*Volume specified in number of individual products (Tapes, maps, reports....)

The volume of required space data shows a significant decrease through the 1980-1990 decade, from approximately 60 to 20 Gigabits/ year. This is due primarily to the user's perception of two trends: 1) that of current plans for omitting SAR's from future civilian space systems e.g. NOAA: further, that whichever Agency should take over the responsibility for a spaceborne SAR will perform the associated information extraction reduction in house. As such, the postulated decrease in volume of space data may be more apparent than real, caused by the as yet imprecise definition of the U.S. Government's space plans in this particular Discipline; 2) the assumption that much of the effort in the Coastal Zone discipline will have strong commonalities with that pertaining to Ocean Processes, since the geographic area covered by the Coastal zone is small with respect to that covered by the Oceans. The volume required of auxiliary data, from Table 5.2, is approximately one fifth that of the space data, growing to almost half by the end of the forthcoming decade.

From Figure 5.1, OSTA's program is split between research and technology transfer efforts. Table 5.2 shows that the acceptable time lapse of data delivery for research efforts is of order four weeks.

Figure 5.1 shows for the post-1986 time frame a maturing of technology transfer activities. These could acquire two forms: 1) algorithms and models developed by NASA researchers are tested by other federal agencies upon their facilities, in this case NOAA's; or 2) they are tested on NASA facilities with participation from sister agency personnel.

TABLE 5.2

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: COASTAL ZONE (OBSERVATIONS)

	R & D ACTIVITY				
	WIND WAVE INTERACTION	COASTAL AND ESTUARY CIRCULATION	COASTAL THERMAL BALANCE	COASTAL BIOLOGY AND CHEMISTRY	COASTAL BOTTOM TOPOGRAPHY
REQUIREMENTS	CZ1	CZ2	CZ3	CZ4	CZ5
Horizontal Resolution (KM)					
Minimum	0.02	0.1	0.1	0.01	0.[illegible]
Maximum	10	500	10	500	0.1
Modal	0.02-0.1	0.1	0.1-10	0.1	0.[illegible]
Vertical Resolution (KM)					
Minimum	N.A.	N.A.	N.A.	N.A.	N.A.
Maximum	N.A.	N.A.	N.A.	N.A.	N.A.
Modal	N.A.	N.A.	N.A.	N.A.	N.A.
Frequency					
Minimum	12 Hrs.	1 Day	12 Hrs.	1 Day	4 Weeks
Maximum	2.4 Hrs.	1 Hr.	2.4 Hrs.	1 Year	4 Weeks
Modal	2.4-12 Hrs.	1 - 24 Hrs.	2.4-12 Hrs.	1 Day	4 Weeks
Data Delivery					
Research Investigations	4 Weeks	4 Weeks	4 Weeks	4 Weeks	4 Weeks
Technology Transfer	3-24 Hrs	3-24 Hrs	3-24 Hrs	1 Day	4 Weeks

TABLE 5.2 (Cont'd)

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: COASTAL ZONE

(SPECIAL SERVICES)

REQUIREMENTS	R & D ACTIVITY				
	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5
Provide Satellite Data Mini-Tapes for Specified Geographic Locations	X	X	X	X	
Provide Auxiliary Data in a Computer Compatible Form	X	X	X	X	
Provide the Capability for Investigators to Perform Interactive Data Processing on a Central Data Service Computer via Remote Terminal	X	X	X		
Provide Digital Tapes of each Spectral Image				X	
Provide Multi-Spectral Comparisons of Satellite Imagery				X	
Provide Photographic Products as Available				X	

(STANDARD ALGORITHMS)

REQUIREMENTS	R & D ACTIVITY				
	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5
Sea Surface Wind Shear	X				
Sea State Index	X				
Geostrophic Flows		X			
Ekman Flows and Depth		X			
Location of Areas of Upwelling		X			
Ocean Temperature Profile Estimators			X		
Fish Yield Models				X	
Chlorophyll				X	
Phytoplankton/Zooplankton				X	
Bottom Topography					X

The first form of transfer does not impact ADS because by current definition, ADS is intended to service NASA researchers only. In the second event, the timeliness requirements for data transfer would be of order of hours to one day.

Thus, for research efforts, throughout the 1980-1990 decade, ADS data transfer requirements can be satisfied by a service of data rate comparable to that of the U.S. mail.

In the latter part of the decade, beginning approximately 1986, the need for links becomes more stringent in spite of the reduced data load assumed by the users; and then only in the hypothesis that a substantial amount of technology transfer be performed employing NASA facilities. Note in this regard, Table 5.3, that the users specify real-time data deliveries for technology transfer. The uncertainty is whether such transfer will occur on NASA facilities or on the facilities of the primary Federal users interested in oceanic data.

The slow data delivery requirements of the early time frame do not necessarily connote that electronic linkages are not desirable. They simply indicate that the choice of the link is driven by economic cost-effectiveness rather than by technical urgency. For example, a plausible ADS scenario may well incorporate a centralized accounting, scheduling and data traffic monitoring facility; which maintains track of expenditures on the part of the users, supplies them budgetary estimates, advises them of impending depletion of project funds. Further analysis might reveal that such centralized management function

TABLE 5.3

DATA SERVICE REQUIREMENTS FOR THE COASTAL ZONE DISCIPLINE

		WIND/WAVE INTERACTION	COASTAL & ESTUARY CIRCULATION	COASTAL THERMAL BALANCE	COASTAL BIOLOGY & CHEMISTRY	COASTAL BOTTOM TOPOGRAPHY
DATA LOCATION	Data Catalog	■	■	■	■	■
	Data Dictionary	■	■	■	■	■
	Computer Search	●	●	●	●	●
DATA EDITING	Quality Control	■	■	■	■	■
	Data Sorting	●	●	●	●	●
REFORMATTING	Form Conversion	●	●	●	●	●
	Code Conversion					
	Coordinate Conversion					
	Scale Conversion					●
ASSEMBLY	Data Segment Preparation	●	●	●	●	●
	Data Set Preparation	●	●	●	●	●
DATA INTEGRATION	Single-Source Multi-temporal Data Registration					
	Single-Source Multi-temporal Data Merging					
	Multi-Source Uni-temporal Data Registration	●	●	●	●	
	Multi-Source Uni temporal Data Merging					
	Data Gridding	●	●	●		●
	Data Overlay					
	Image Mosaicing					
SPECIAL PROCESSING	Radiometric Correction	●	●	●	●	●
	Geometric Correction	●	●	●	●	●
	Other					
DATA MGM'T	Data Archiving					
	Data Delivery	1 ■	1 ■	1 ■	1 ■	
OTHER		2 ■	2 ■	2 ■	2 ■	2 ■

■ High Value Data Service ● Desirable Data Service

Note 1: Real Time for Tech. Transfer
2: Comprehensive Data Documentation

can be performed more cost-effectively through use of electronic data links than through other conventional alternatives; quite apart from considerations of speed.

As a gross sizing of the "electronic link" alternative during the "slow" R&D time frame, the corresponding transfer requirements are such as to engage the equivalent of approximately 12 data links of 1,200 bps capacity each, operating on a one shift, normal work week basis.

Because the driver is economics, not technology, system tradeoffs can exploit to the fullest special tariff structures and price breaks: e.g. discounts for off-time operation, quantity savings from use of bulk bandwidths, use of satellite links whenever transfer distance exceeds the cost breakpoint (currently of order 900 kilometers).

Analysis of Tables 5.3 and 5.2 permits the inference that user services related to imagery manipulation---e.g. geocoding, superposition of formats, gridding---will impose significant technological requirements upon ADS. This is because relatively high spatial resolutions are required to satisfy the users.

Users need to have available approximately 10 significant types of algorithms, Table 5.2. A potential evolutionary trend in the latter part of the 1980-1990 decade is the transition from user-peculiar development of these algorithms to their routine use--after the necessary confidence resulting from high "batting averages" will have been achieved.

Such an evolutionary development would open the ADS to the opportunity of providing a centralized algorithm processing function. Algorithms which reach fruition would be transferred to this function for conventional processing: the researcher would retain the function of developing the newer generations of algorithms.

5.3 Implications of ADS on the Coastal Zone Discipline

Analysis of the Coastal Zone Discipline user requirements yields the following key data-related points:

- Approximately 50% of the Coastal Zone Discipline's users is involved in technology demonstration projects such as sea-state assessment applied to offshore drilling, ship routing. These users ultimately desire data turnaround in 1-3 hours: some would be satisfied with 24-72 hours. Current performance is order 1-2 months.

  Near real time delivery time is the key to successful performance by end-users, hence by technology transfer investigations: it is required by approximately 1986. Pre-1986 needs are conventionally met by unique data systems or are circumvented by simulations.

- The remainder 50% of the users are engaged in research activities. They consider the current 1-2 month data delivery time sufficient.

- Research users are impacted by cost considerations brought about by the deficiencies of the current data system, principal among which are:

a) conventional sources of key auxiliary data do not provide updated or sufficiently documented data catalogs and directories;

b) data quality is often questionable;

c) adequate geocoding information is not provided in the catalogs for the key auxiliary data.

For these reasons, users are forced to acquire "total cruise" data access cost with concommitant time delays.

- Users generally desire a data directory augmented by a running rapidly available log of the pertinence and quality characteristics of *individual data. Therefore, an important ADS function identified is the maintenance of a comprehensive, continuously updated catalog identifying not only location and general contend of the data, but additionally providing indications as to the quality of each datum.*

  The effort required to prepare a comprehensive catalog of the historical data represents a signigicant undertaking: yet it would significantly benefit Coastal Zone, Ocean Processes, Cryosphere, Global Weather and Climate Users.

- Data costs are not a significant consideration to technology transfer users who generally do not deal with historic data and usually work in geographically restricted areas.

- Data merging and reformatting represents a major requirement for Coastal Zone users engaged in both research and technology transfer. This is particularly true since most auxiliary data is not in digitial format and is not generally amenable to optical overlay processes. Thus, many users forego using large amounts of auxiliary data; they opt for the smaller quantity of data already available in digital form, thus limiting the completeness and quality of the results.

In summary, the principal impact of an ADS upon the users of the Coastal Zone Discipline would be economic, i.e. a significant reduction of the time and expense required for obtaining data in usable formats.

These economies would contribute to promoting the exploitation of auxiliary data not currently accessed, with consequent enhancement of the quality and completeness of the research results.

Three ADS functions would most significantly promote increased efficiency:

- A comprehensive data directory and catalog to include concurrent running data log.
- Cost effective data merging and reformatting services
- Acceleration of data delivery times to support technology demonstrations.

6.1 Description of Objectives and Content

NOAA and the U.S. Coast Guard are the principal Federal agencies with responsibility for collection and distribution of sea ice information. USCG prepares and broadcasts iceberg location bulletins for the North Atlantic shipping lanes during the international ice patrol. NOAA is responsible for collecting and evaluating cryosphere data for assessment of its impact on the atmospheric and oceanic environments.

Information about the cryosphere is required for weather and climate applications, vessel navigation, fishing operations and environmental monitoring. The discovery of oil in Alaska and the recognition of major fisheries in the Arctic and Antarctic have brought new attention to the polar regions. The importance of remote sensing information to the support of Great Lakes winter navigation has also been demonstrated. These requirements have created the increased need for continuous ice information over large areas.

The objective of OSTA's Cryosphere Discipline program is to develop and improve the capability to remotely observe semipermanent and transitory ice and snow masses from space, so that the user community will be able to optimally exploit such observations for the satisfaction of their needs. Both the dynamics of this ice and snow cover and the impact of the dynamics on polar ecology is of interest.

Current OSTA Program

OSTA's efforts comprising the Cryosphere Discipline fall into four categories of R&D activities.

CY 1 Sea Ice Dynamics

Techniques are under development to provide interpretive algorithms for assessing the lateral and horizonal motions of sea ice.

Significance is to provide information for ship routing in polar regions, for polar research expeditions and oil-site scheduling and resupply. Ice motions are also needed to guide crab fleet deployment and to estimate ship and rig design criteria.

CY 2 Iceberg Dynamics

Techniques for the measurement of iceberg dynamics leading to interpretive algorithms for assessing the formation and propagation of icebergs are under development.

Icebergs are seasonal hazards to navigation. The U.S. provides iceberg forecasting services from the Coast Guard operated International Ice Patrol in the North Atlantic and from the NAVY/NOAA Joint Ice Survey Office in Alaska and the Antarctic.

CY 3 Ice Impact on Weather and Climate

Remote sensing techniques are being developed to assess the changes in major ice sheets, sea ice, and glaciers caused by cryosphere interactions with the atmosphere and sea.

Glacial, sea ice and sheet ice patterns can be indicative of major long term climate changes. How the ice cover exchanges heat and mass with the fluid environments can significantly affect global weather and has a direct influence on U.S. weather.

CY 4 Polar Ecology

Techniques for assessing negative (pollutant spills) and positive (ocean turbidity patterns, chlorophyll, and salinity) patterns are under development and improvement.

The polar regions are a mixture of untapped food sources like krill, crabs, and of endàngered species like polar bears, whales, walruses, seals, caribou, Canadian geese. All of these species need an active resource management program to keep them viable. Petroleum pollutants are a rising problem with the increase in drilling in the Arctic regions.

Near Future OSTA Program

The emphasis of the Cryosphere Program is on the assessment of active and passive all weather remote sensors to measure surface and near subsurface ice phenomena. Correlations are then to be developed to allow the development of large scale dynamic/thermodynamic ice models. A strong user oriented program has been undertaken under the Cryosphere program with yearly joint field tests involving NASA, university researchers, industry and other government agencies with operational and research interest in the polar regions. International cooperation is particularly important in the polar regions: parallel artic studies are in process in Canada and with ESA, with industrial participation (e.g., Canadian Oil Company ASVT's). SEASAT-A and NIMBUS-7 have provided a base of satellite data to compare with earlier or parallel exploratory studies utilizing aircraft and in-situ sensors.

The research elements of the near term Cryosphere program are:

- Snow/ice-weather/climate interaction modeling
- Parameter extraction from polar ocean color observations
- Ice sheet mass balance modeling
- Snow/ice property extraction from microwave data

The principal related technology development and utilization is in the following areas:

- Refinement of iceberg tracking techniques
- Demonstrate cost effective systems for providing sea ice location information
- Assessment of active and passive microwave sensors to measure surface and subsurface ice properties.

Near term program activities will focus on formulation of a joint U.S./Canadian strategy for ice monitoring and upon proposed system studies to establish the need for a separate Cryosphere Monitoring System (ICEX) or if the needed data can be obtained from a multipurpose system such as the proposed NOSS.

Future OSTA Program

The specific objectives of the future Cryosphere Program are:

- Determine the interactions and develop correlations between active and passive all-weather sensors and surface and subsurface ice phenomena

- Describe ice processes using large scale dynamic/thermodynamic ice models that incorporate remotely measured parameters.

- Provide a Cryosphere information system through the development of improved observation and information delivery systems.

Figure 6.1 presents a graphic synopsis of OSTA's Cryosphere Discipline Program.

The first portion of the Figure reflects the space missions, current and projected, whose data products support the Program. The subsequent portion and continuation sheet reflects the Program's endeavors for each identified R&D Activity.

Each element is referenced to its pertinent source documents; their titles are listed at the Figure's end.

6.2 Relationships between Data Services and the Cryosphere Discipline

Figure 6.2 summarizes the requirements for data products expressed by the users.

Users are interested in obtaining parameters. These are intermediate information products derived from sensor measurements, elaborated via the application of appropriate algorithms. For example, ocean current information derives from remotely sensed altimetry data elaborated statistically in conjunction with orbital parameters, atmospheric index of refraction, sensor calibration data.

FIGURE 6.1

CRYOSPHERE DISCIPLINE TIMELINE

OSTA MISSIONS

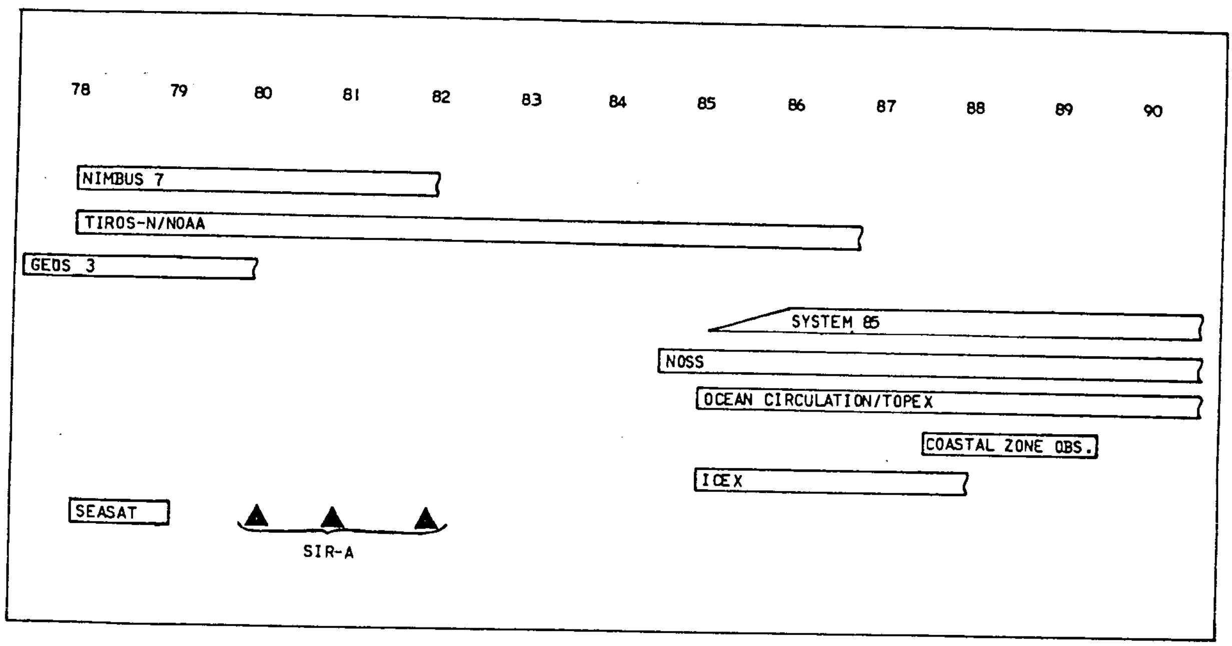
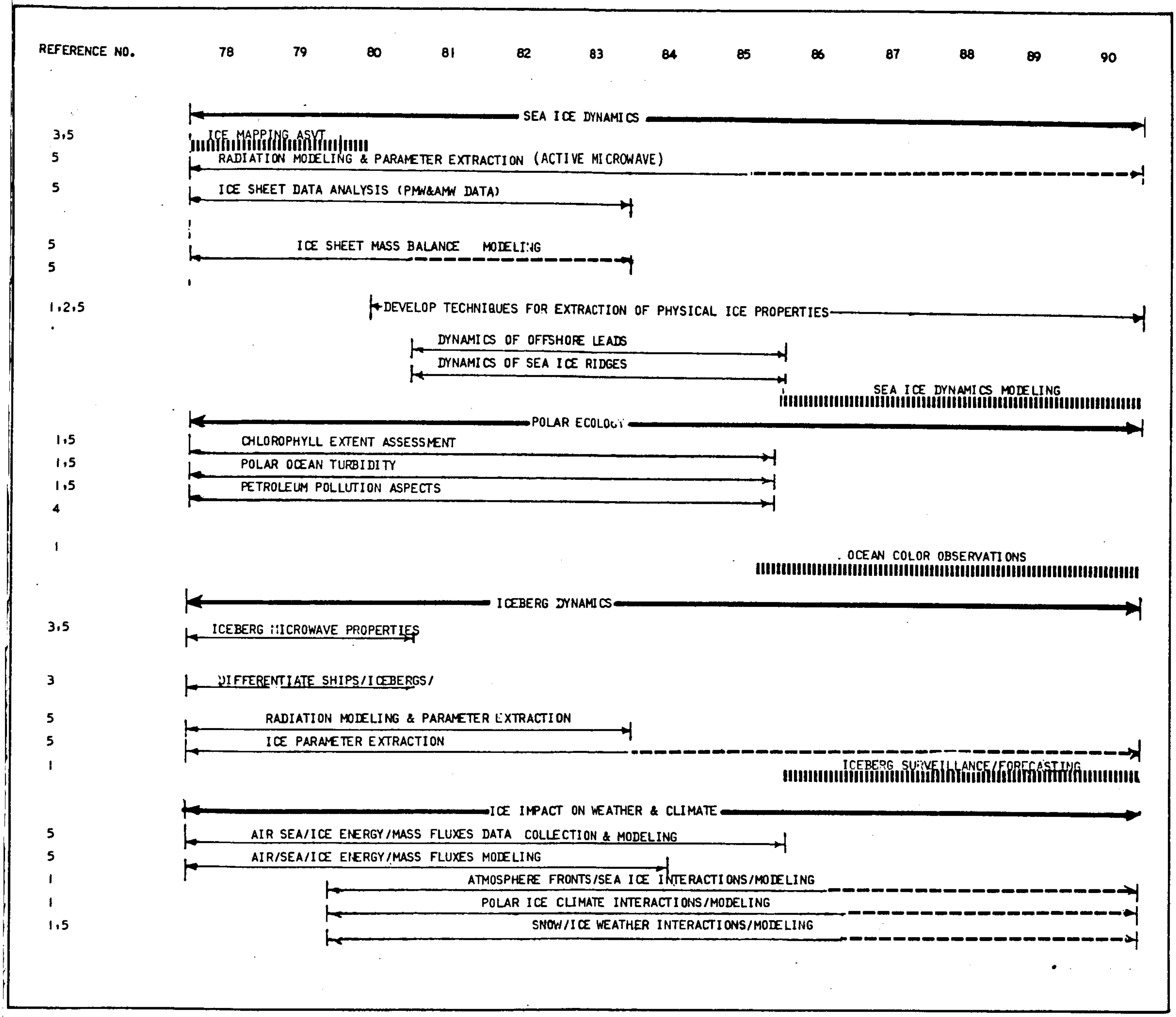


FIGURE 6.1 (cont'd)

CRYOSPHERE DISCIPLINE TIMELINE

R & D ACTIVITIES



REFERENCES:

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2) ICE EXPERIMENT (ICEX) FINAL REPORT OF SCIENCE & APPLICATION WAORKING GROUP, 1979
3) OCEANOLOGY SUBPROGRAM PLANS, 1977
4) OCEANIC PROCESSES PROGRAM 5 YEAR PLAN
5) RTOPS 79/80
6) RESOURCE OBSERVATIONS 5 YEAR PLAN: FY81-85 PRESENTATION TO NASA PLANNING COUNCIL, 1979

LEGEND

1 Flight Mission
2 Program Emphasis
3 R&D Activity
4 Continuing Activity
5 Technology Transfer (Pilot/Application Tests Etc.)
6 Short Term Event
7 Initial Operational Capability
8 All Investigation Classes

FIGURE 6.2

USER REQUIREMENTS FOR SPACE DATA PRODUCTS, CRYOSPHERE DISCIPLINE

	NOAA	GEOS 3	SEASAT				NIMBUS 7		TIROS N	SHUTTLE	NOSS					SHUTTLE	SYSTEM 85	ICEX					COASTSAT	
PARAMETERS	VHRR	ALT	SAR	SASS	ALT	SMMR	SMMR	CZCS	AVHRR	SIR	CZCS	SCAT	AVHRR	ALT	LAMMR	ERSAR	AVHRR-FOLLOW	LAMMR	PIMR	IEAS	SCAT	WSIR	COLORI-METER	
ICE/SNOW EXTENT	●			●		●	●	●	●	●	●		●		●	●	●	●	●			●	●	
ICE DRIFT RATE	●		●			●	●		●				●		●	●	●	●				●	●	
ICE THICKNESS		●			●									●						●				
ICE SURFACE ROUGHNESS				●								●									●			
MULTI-SPECTRAL OCEAN REFLECTANCE (COLOR)								●			●												●	
OCEAN CURRENT		●		●	●							●		●						●	●			
ICE/SNOW TEMP.	●					●	●		●				●		●		●	●						
ICE LEAD LOCATION	●			●		●	●	●	●	●	●		●		●	●	●	●	●			●	●	
ICEBERG LOCATION	●			●		●	●	●	●	●	●		●		●	●	●	●	●			●	●	
ICE SNOW ALBEDO				MEASURED BY AIRCRAFT SENSORS AND PORTABLE FIELD SPECTROMETER																				
DATA BANKS																								
JPL/SEASAT, CDHF			●	●	●	●																		
NOAA/NESS	●		●	●	●	●			●								●							
NCC/SDS	●								●															
NSSDC		●					●	●		●						●							●	
NOSS/PPF											●	●	●	●	●									
GSFC/IPD																		●	●	●	●	●		
EROS										●						●								
PRODUCTS																								**PRODUCT TOTALS**
1980 TAPES/YR.	54	11	75	6	3	75	129	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	358
1980 IMAGES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1980 OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1980 G BITS/YR.	2	0.4	3	0.2	0.1	3	5	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13
1985 TAPES/YR.	-	-	-	-	-	-	-	-	54	26	5	6	30	14	154	-	-	-	-	-	-	-	-	289
1985 IMAGES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1985 OTHERS/YR.	-	-	-	-	-	-	-	-	-	10FS	-	-	-	-	-	-	-	-	-	-	-	-	-	10 FS
1985 G BITS/YR.	-	-	-	-	-	-	-	-	2	1	0.2	0.2	1	0.5	5	-	-	-	-	-	-	-	-	10
1990 TAPES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	79	10	138	134	62	19	6	10	5	463
1990 IMAGES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1990 OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5 FS	-	-	-	-	-	5FS	-	10FS
1990 G BITS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0.4	5	5	2	0.7	0.2	0.4	0.2	16

At this time, NASA users in the Cryosphere Discipline are in the process of developing such algorithms. For this purpose, they wish to receive raw space data, augmented by the auxiliary data summarized in Table 6.1.

The volume of required space data shows a moderate increase through the 1980-1990 decade, from approxiamtely 12 to 16 Gigabits/year. The volume required of auxiliary data, from Table 6.1 approximately equals that of the space data.

From Figure 6.1 OSTA's program is split between research and technology transfer. Table 6.2 shows that the acceptable time lapse of data delivery for research efforts is of order four weeks.

Figure 6.1 shows for the post-1985 time frame a maturing of technology transfer activities. These could acquire two forms: 1) algorithms and models developed by NASA researchers are tested by other federal agencies upon their facilities, in this case NOAA's; or 2) they are tested on NASA facilities with participation from sister agency personnel.

The first form of transfer does not impact ADS because by current definition, ADS is intended to service NASA researchers only. In the second event, the timeliness requirements for data transfer would be: of the same for two R&D activities related to Climate and Polar Ecology: hours to one day for Iceberg Dynamics, hours to one week for Sea Ice Dynamics.

TABLE 6.1

USER REQUIREMENTS FOR AUXILIARY DATA PRODUCTS, CRYOSPHERE DISCIPLINE

TYPE OF DATA	DATA PRODUCT FORMAT	SOURCE	ESTIMATED YEARLY PRODUCT VOLUME*					USE OF DATA PRODUCT
			CY 1	CY 2	CY 3	CY 4	TOTAL	
Ocean Biological Data	Microfilmed cruise record (contains data on distribution of marine organisms and pollutants) data available by cruise, area and time sort)	EDIS (NODC) SCRIPPS	-	-	5	-	5	Calibration and verification of satellite biological and pollutant observations from ocean color
Sea Ice Surveys	Weekly Digitized Map of sea ice (produced daily from naval and commercial ship ice observations)	FWF	132	48	-	48	228	Verification of satellite derived ice locations and drift rates
Surface Current Analysis Data	Monthly Fine Grid map of the average current down to the depth of the thermocline. Derived from flow components based on the local temperature structure and modified for salinity effects and integrated wind stress	EDIS (NODC)	33	12	3	12	60	Estimation of sea ice drift rates and directions between satellite observations
Data Buoy	Monthly regional digital (800 BPI) data buoy summary tape of sea surface temperature, wind, air temperature, currents and wave spectra	EDIS (NODC, NOAA/DBO)	33	-	3	3	39	Verification and calibration of satellite sea surface data.
Synoptic Ocean Meteorologic Observations	7 Channel (556 BPI) digital tape of surface and upper air meteorologic data (wind, sea surface temperature, sea state, air temperature, pressure and humidity. From Northern Hemisphere coastal and ocean stations	EDIS (NCC, NODC, NMC, NMFS)	110	-	10	40	160	Calibration and verification of satellite data for input to cryosphere-atmosphere heat flux sub-models
NANSEN Cast Data	Digital (1600 BPI) tape of STD data (surface to 11,999 m)	EDIS (NODC)	11	-	1	1	13	Calibration and extrapolation of satellite sea surface temperature and salinity for estimation of ice melt rates

*Volume specified in number of individual products (Tapes, maps, reports....)

TABLE 6.2

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: CRYOSPHERE

(OBSERVATIONS)

	R & D ACTIVITY			
	SEA ICE DYNAMICS	ICE BERG DYNAMICS	POLAR ECOLOGY	ICE IMPACT ON WEATHER & CLIMATE
REQUIREMENTS	CY1	CY2	CY3	CY4
Horizontal Resolution (KM)				
Minimum	0.1	0.005	0.01	0.05
Maximum	100	0.1	1	0.5
Modal	0.1-20	0.005-0.1	1	0.05-0.5
Vertical Resolution				
Minimum	N.A.	N.A.	N.A.	N.A.
Maximum	N.A.	N.A.	N.A.	N.A.
Modal	N.A.	N.A.	N.A.	N.A.
Frequency				
Minimum	1 Year	1 Day	1 Day	4 Weeks
Maximum	2.4 Hrs.	3 Hrs.	1 Day	4 Weeks
Modal	6 Hrs.	3-24 Hrs.	1 Day	4 Weeks
Data Delivery				
Research Investigations	4 Weeks	4 Weeks	4 Weeks	4 Weeks
Technology Transfer	3 Hrs-7 Days	3-24 Hrs.	1-3 Days	N.A.

TABLE 6.2 (cont'd)

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: CRYOSPHERE

(SPECIAL SERVICES)

REQUIREMENTS	R & D ACTIVITY CY 1	CY 2	CY 3	CY 4
Satellite Images Registered to Service Charts	X	X		
Quick Reaction Response during Critical Ice Movement Period	X			
Formation of Regional Data Sets for Developmemt of Sea Ice Movement Models	X			
Maintenance of Regional Sea Ice Data Sets to Support Forecast Model Improvements	X			
Format Cryosphere Related Observation in Gridded, Registered, Spatially and Temporally Averaged Formats				X
Calibrate and Extract Cryosphere-Related Parameters from Raw Satellite Data and Archive and Distribute these Observations				X

(STANDARD ALGORITHMS)

REQUIREMENTS	R & D ACTIVITY CY 1	CY 2	CY 3	CY 4
Sea Ice Movement	X			
Ice Age	X			
Ice Deformation	X			
Salinity	X			
Iceberg Tracking		X		
Snow Surface Temperature				X
Snow Ice Fraction				X

Thus, for research efforts, throughout the 1980-1990 decade, ADS data transfer requirements can be satisfied by a service of data rate comparable to that of the U.S. mail.

In the latter part of the decade, beginning approximately 1985, the need for links becomes more stringent; and then only in the hypothesis that a substantial amount of technology transfer be performed employing NASA facilities.

The slow data delivery requirements of the early time frame do not necessarily connote that electronic linkages are not desirable. They simply indicate that the choice of the link is driven by economic cost-effectiveness rather than by technical urgency. For example, a plausible ADS scenario may well incorporate a centralized accounting, scheduling and data traffic monitoring facility; which maintains track of expenditures on the part of the users, supplies them budgetary estimates, advises them of impending depletion of project funds. Further analysis might reveal that such centralized management function can be performed more cost-effectively through use of electronic data links than through other conventional alternatives; quite apart from considerations of speed.

As a gross sizing of the "electronic link" alternative during the "slow" R&D time frame, the corresponding transfer requirements are such as to engage the equivalent of approximately 2 data links of 1,200 bps capacity each, operating on a one shift, normal work week basis.

Because the driver is economics, not technology, system tradeoffs can exploit to the fullest special tariff structures and price breaks: e.g. discounts for off-time operation, quantity savings from use of bulk bandwidths, use of satellite links whenever transfer distance exceeds the cost breakpoint (currently of order 900 kilometers).

Analysis of Tables 6.2 and 6.3 permits the further inference that user services related to imagery manipulation--e.g. geocoding, superposition of formats, gridding--will impose significant technological requirements upon ADS. This is because relatively low spatial resolutions are required to satisfy the users.

Users need to have available approximately 7 significant types of algorithms, Table 6.2. A potential evolutionary trend in the latter part of the 1980-1990 decade is the transition from user-peculiar development of these algorithms to their routine use-after the necessary confidence resulting from high "Batting averages" will have been achieved.

Such an evolutionary development would open the ADS to the opportunity of providing a centralized algorithm processing function. Algorithms which reach fruition would be transferred to this function for conventional processing: the Researcher would retain the function of developing the newer generations of algorithms.

TABLE 6.3

DATA SERVICE REQUIREMENTS FOR THE CRYOSPHERE DISCIPLINE

		SEA ICE DYNAMICS	ICE BERG DYNAMICS	POLAR ECOLOGY	WEATHER & CLIMATE IMPACT
DATA LOCATION	Data Catalog	■	■	■	●
	Data Dictionary	■	■	■	●
	Computer Search	●	●	●	
DATA EDITING	Quality Control	■	■	■	
	Data Sorting				
REFORMATTING	Form Conversion				
	Code Conversion				
	Coordinate Conversion				
	Scale Conversion				
ASSEMBLY	Data Segment Preparation	●	●	●	
	Data Set Preparation	●	●	●	
DATA INTEGRATION	Single-Source Multi-temporal Data Registration				●
	Single-Source Multi-temporal Data Merging	●	●	●	
	Multi-Source Uni-temporal Data Registration				●
	Multi-Source Uni temporal Data Merging				●
	Data Gridding	●	●		●
	Data Overlay				
	Image Mosaicing				
SPECIAL PROCESSING	Radiometric Correction	●	●	●	
	Geometric Correction	●	●	●	
	Other				
DATA MGM'T	Data Archiving				●
	Data Delivery	1 ■	1 ■	■	
OTHER		2 ■	2 ■	2 ■	3 ■

Note 1: Real Time for Tech. Transfer
Note 2: Comprehensive Data Documentation
Note 3: Prepare Data Summaries of Monthly Snow/Ice Cover

■ High Value Data Service ● Desirable Data Service

6.3 Implications of ADS on the Cryosphere Discipline

Analysis of the Cryosphere Discipline user requirements yields the following key data related points:

- Approximately 45% of the Cryosphere Discipline's users are involved in technology demonstration projects, e.g. sea ice assessment applied to ship routing. They ultimately desire data turnaround of 6 - 12 hours; some would be satisfied with 24 - 72 hours. Current capabilities are of the order 1-2 months. The real time data link demonstration with Seasat provided data delivery within 24 hours.

  The near real time data delivery time is the key to successful performance by end users: hence by technology transfer investigators: it is required by approximately 1985. Pre-1985 needs are conventionally met by unique data systems or are circumvented by simulations.

- The remainder 55% of the users are engaged in research activities. They consider the current 1-2 month data delivery time sufficient.

- Research users are impacted by cost considerations brought about by the deficiences of the current data system, principal among which are:

  a) conventional sources of key auxiliary data do not provide updated or sufficiently documented data catalogs and directories;

  b) data quality is often questionable;

  c) adequate geocoding information is not provided in the catalogs for the key auxiliary data.

  For these reasons, users are forced to acquire "total cruise" data at excess cost and with concommitant time delays.

Users generally desire a data directory augmented by a running, rapidly available log of the pertinence and quality characteristics of *individual data. Therefore, an important ADS function identified is the maintenance of a comprehensive, continually updated catalog identifying not only location and general content of the data, but additionally providing indications as to the quality of each datum.*

Users generally desire a data directory augmented by a running, rapidly available log of the pertinence and quality characteristics of *individual data.* The cryosphere data catalog and directory service would also be very valuable to the other ocean and weather related ADS discipline users.

- Data costs are not a major consideration to technology transfer users who generally do not deal with historic data and usually work in geographically restricted areas.

- Data merging and reformatting represents a major requirement for Cryosphere users engaged in both research and technology transfer. This is particularly true since most auxiliary data is not in digital format and is not generally amenable to optical overlay processes. Thus, many users forego using large amounts of auxiliary data; they opt for the smaller quantity of data already available in digital form, thus limiting the completeness and quality of the results.

In summary, the principal impact of an ADS upon the users of the Cryosphere Discipline would be economic, i.e. significant reduction of time and expense required for obtaining data in usable formats.

These economies would contribute to promoting the exploitation of auxiliary data not currently accessed, with consequent enhancement of the quality and completeness of the research results.

Three ADS functions would most significantly promote increased efficiency:

- A comprehensive data directory and catalog of space and auxiliary data with provisions for concurrent running data log
- Cost effective data merging and reformatting services
- Acceleration of data delivery times to support technology demonstrations

7.1 Description of Objectives and Content

NOAA is the US Federal Agency charged with civilian operational weather activities. NOAA discharges this responsibility through the NWS, National Weather Service. The stated objective of NOAA/NWS's weather activities is "to contribute to the safety, health, welfare, comfort, and convenience of the public, and to meet the needs of all segments of the national economy for general weather information."

Global Weather is the basic NOAA/NWS activity, whose products are the starting point for most interpretive and forecast services. Its core is the global weather model, which consists of a system of mathematical equations, depicting the dynamics of the atmosphere. These are periodically initialized via data collected from approximately 50,000 daily observations. The model's output are predictions of the "state of the atmosphere," i.e. temperatures and pressures at several standard altitudes and for several standard forecast timings. NOAA/NWS specialists augment these basic predictions with machine aided elaborations to incorporate other weather effects, e.g. precipitation, and to adapt them to specific regional conditions. These data subsequently form the basis for the public weather forecast and for predictions by various specialized weather services; e.g. domestic and international aviation services, environmental quality service, agricultural weather service, marine weather services.

The operational global weather models utilized by NOAA/NWS are periodically improved when R&D efforts by specialized research organizations reach a sufficient state of development: e.g. the

Princeton Fluid Dynamics Laboratory, NCAR, NWS itself, DOD, NASA. Principal trends of model improvement are: 1) the achievement of evermore sophisticated understanding of atmospheric phenomena, to enable the incorporation of the corresponding equations into the models; and 2) the achievement of evermore cost effective means to increase the number of measurements throughout the globe, particularly over the oceans where conventional measurements are perforce relatively sparse.

OSTA's Global Weather discipline program provides research and technology support to atmospheric scientists and meteorological user agencies, particularly NOAA and DOD.

General Weather Forecast is the principal application supported by the Global Weather Program. Its objectives are to:

- provide improved observation technology for operational meteorological satellite systems
- improve techniques for extracting meteorological parameters from remotely sensed data
- improve the usefulness of space-derived measurements in describing atmospheric processes and to improve weather forecasts

Historically, OSTA technologies have aimed at: using spaceborne optical, IR, passive microwave sensors to observe meteorological phenomena and measure their key parameters; transmitting timely data to users, local and global; assimilating asynoptic data into existing and developmental numerical models to test measurement strategies and verify the contribution of satellite data. The data sets developed by OSTA scientists include cloud cover, temperature soundings, wind fields from cloud motions.

Current OSTA Program

OSTA's efforts comprising the Global Weather discipline fall into four categories of R&D Activities.

GW 1 Assessment of the Atmosphere's Thermal Balance

Development of data analysis techniques to measure the radiative properties and thermal structure of the atmosphere. Emphasis is on assessing and eliminating spurious contributions from perturbing atmospheric constituents and clouds.

Its significance is that remote sensing techniques supplement conventional point measurements in providing synoptic thermal balance data sets for input to global numerical prediction models. Synoptic data are particularly important over the oceans where conventional meteorologic measurements are limited.

GW 2 Assessment of the Atmosphere's Convective Balance

R&D of analysis techniques for the remote measurement of wind. Current emphasis is on techniques utilizing the motions of clouds and patterns of water vapor: and upon their evaluation in terms of technical feasibility and value to global weather forecasting.

Its significance is that large-scale wind patterns are a key input to advanced weather prediction models. They provide an important contribution to understanding the dynamics of planetary-scale circulation.

GW 3 Assessment of Atmospheric Water Balance

Development of inferential techniques drawn from nephelometry to assess the global atmospheric water balance from regional assessment of precipitable atmospheric water.

Its significance is that synoptic measurements of atmospheric water balance offer greatly improved spatial and temporal resolution over conventional methods, particularly important to assess precipitable water and rainfall over the oceans.

GW 4 Integrated Modeling of Global Weather

Analysis of synoptic data of cloud-and snow cover, surface and atmospheric temperature, moisture profiles and winds, for applicability in new global weather models sensitive to the atmosphere's thermal structure, moisture balance and circulation. The data extraction algorithms developed are evaluated for value to existing global weather models.

Its significance is that current numerical forecast models do not exploit fully the unique information content of satellite data. Development of models specifically designed to accept these data is expected to provide significant improvements to weather forecasting capabilities.

Near Future OSTA Program

The program's philosophy is to:

- support the GARP global weather experiment; and to
- perform scientific research and technology development (SR&T) leading to improved meteorological observation systems, to improved techniques for extracting meteorological parameters from remotely sensed data, and to more accurate forecasts through

the use of satellite data. Major research focus is on measurements of temperature and moisture profiles, atmospheric pressure, winds; technology focus is upon employing various approaches, e.g. IR, microwave, lidar and radar.

The research elements of OSTA's near term Global Weather program are:

- Continued development of techniques for profiling atmospheric temperature and pressure
- Operation of a high resolution IR Spectroscopy Lab to measure atmospheric line parameters
- Continued study of high resolution microwave imagery for the observation of precipitation
- Continued development of passive microwave, water vapor profiles using aircraft platforms
- General circulation studies and energy diagnosis using the GARP DST/GWE data sets

An important technological element of the Global Weather program's activities over the next five years centers on System 85, slated as a new initiative in FY80. Its long-range objective is to develop and demonstrate the next generation of operational meteorologic satellites.

Principal related technology development and utilization is in the following areas:

- Temperature Sounding. Albeit only passive techniques can be considered for the immediate future, highly promising advanced concepts are currently incorporated in the Advanced Meteorological Temperature Sounder (AMTS).

- Pressure. The VAS, a new remote sensor for measuring surface pressure has progressed to the point of technological feasibility: it is a candidate for System 85.
- Lidar. Although lidar technology is not considered for current flight programs, its progress offers significant promise in the near future (FY81-82). The development of an active lidar temperature sounder is anticipated by FY83.
- Microwave Techniques. It is anticipated that a multi-purpose microwave system such as the High Resolution Microwave Imager (HRMI) will be flown on the Shuttle during FY83 to 84.
- Moisture Sounding. Microwave techniques in the millimeter range have shown promise for moisture sounding and possibly observation of rainfall over land surfaces. Development is planned of a moisture sounding capability that could be demonstrated in conjunction with the multi-purpose microwave Shuttle system.

Future OSTA Program

The goal is to design, develop and demonstrate improved capabilities to acquire and process global satellite observations of meteorological parameters to:

- Continue the R&D on remotely sensed data and techniques leading to improved understanding of the processes which influence the large-scale behavior of the atmosphere;
- and to improve the accuracy of mid-range (greater than 3 day) weather forecasts;
- and to explore techniques to improve long range weather forecasting (30 days and beyond)

Identified OSTA plans for the early 1985-1990 time period include evaluation of AMTS data for use in atmospheric thermal balance assessment, and of lidar techniques for temperature profiling, expected available by 85-86. The decade's later portion will be dominated by the exploitation of the new data expected from System 85.

Figure 7.1 presents a graphic synopsis of OSTA's Global Weather Program.

The first portion of the Figure reflects the space missions, current and projected, whose data products support the Program. The subsequent portion and continuation sheet reflects the Program's endeavors for each identified R&D Activity.

Each element is referenced to its pertinent source documents; their titles are listed at the Figure's end.

7.2 Relationships between Data Services and the Global Weather Discipline

Figure 7.2 summarizes the requirements for data products expressed by the users.

Users are interested in obtaining parameters. These are intermediate information products derived from sensor measurements, elaborated via the application of appropriate algorithms. For example, surface temperature information derives from remotely sensed radiance data elaborated in conjunction with surface emissivity, atmospheric absorptions, sensor calibration data.

FIGURE 7.1

GLOBAL WEATHER DISCIPLINE TIMELINE

OSTA MISSIONS

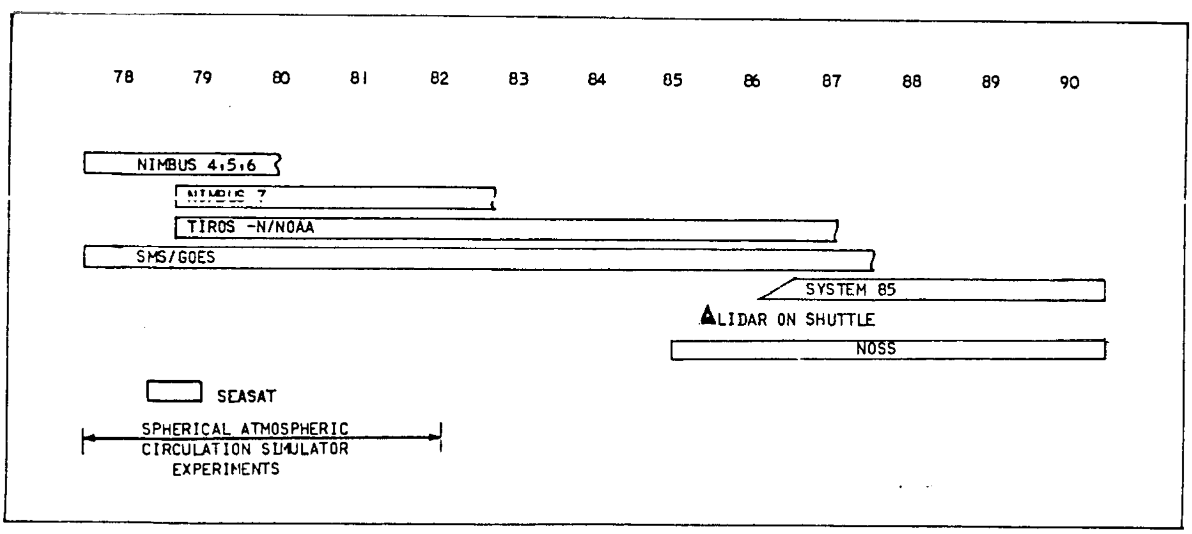
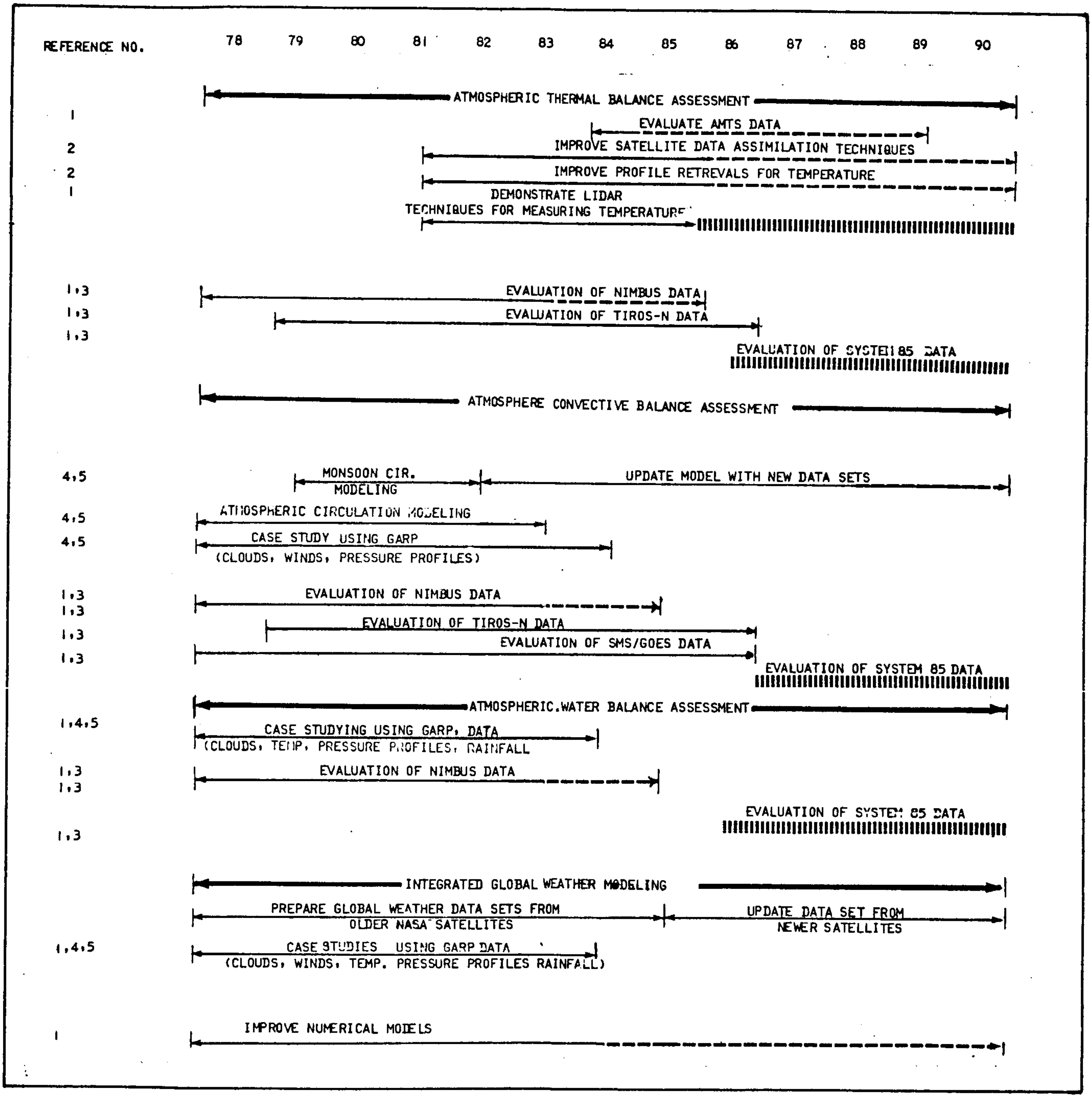


FIGURE 7.1

GLOBAL WEATHER DISCIPLINE TIMELINE

R & D ACTIVITIES



REFERENCES
1) ENVIRONMENTAL OBSERVATIONS REPORT 10 YEAR OSTA PLAN, 1979 (PRELIMINARY)
2) NASA 5 YEAR PLANNING, 1979
3) ENVIRONMENTAL OBSERVATIONS DIVISION 5 YEAR PLANNING PROPOSAL TO NASA PLANNING COUNCIL, 1979
4) RTOPS
5) AN

LEGEND

1 Flight Mission
2 Program Emphasis
3 R&D Activity
4 Continuing Activity
5 Technology Transfer (Pilot/Application Tests Etc.)
6 Short Term Event
7 Initial Operational Capability
8 All Investigation Classes

FIGURE 7.2

USER REQUIREMENTS FOR SPACE DATA PRODUCTS, GLOBAL WEATHER DISCIPLINE

		NOAA		NIMBUS 6			SEASAT A	NIMBUS 7	METEORSAT	GOES	TIROS N		SYSTEM 85		NOSS	
PARAMETERS		VTPR	VHRR	HIRS	SCAMS	ESMR	SMMR	SMMR	- - -	VISSR	(TOVS) HIRS II	AVHRR	VISSR FOLLOW	AVHRR FOLLOW	LAMMR	
SURFACE TEMP. (LAND)		●	●	●	●	●	●	●		●	●	●	●	●	●	
VERTICAL TEMP. PROFILE		●		●	●						●					
CLOUD COVER			●	●						●		●	●	●		
CLOUD HEIGHT				●									●			
CLOUD THICKNESS					●											
SURFACE WIND SPEEDS							●	●							●	
VERTICAL WIND PROFILES							●	●		●			●		●	
PRECIPITATION RATE							●	●							●	
CLOUD PARTICLE SIZE																
CLOUD TOP THERMO-DYNAMIC PHASE																
SNOW/ICE COVER			●			●	●	●	●	●		●	●	●	●	
AEROSOLS			●									●		●		
DATA BANKS																
NCC/SDS		●	●				●			●	●	●	●	●		
NOAA/NESS		●	●	●			●			●	●	●	●	●		
NSSDC				●	●	●		●		●						
GSFC/IPD					●			●								
ESOC									●							
NOSS/PPF															●	
PRODUCTS																**PRODUCT TOTALS**
1980	TAPES/YR.	260	180	170	300	132	42	197	45	45	150	45	-	-	-	1566
	IMAGES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	G BITS/YR.	9	6	6	11	5	1	7	2	2	5	2	-	-	-	55
1985	TAPES/YR.	-	-	-	-	-	-	-	-	-	240	450	890	450	1040	3070
	IMAGES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	G BITS/YR.	-	-	-	-	-	-	-	-	-	8	16	31	16	36	107
1990	TAPES/YR.	-	-	-	-	-	-	-	-	-	-	-	1370	680	1040	3090
	IMAGES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	G BITS/YR.	-	-	-	-	-	-	-	-	-	-	-	48	24	36	108

At this time, NASA users in the Global Weather Discipline are in the process of developing such algorithms. For this purpose, they wish to receive raw space data, augmented by the auxiliary data summarized in Table 7.1.

The volume of required space data shows a moderate increase through the 1980-1990 decade, from approximately 70 to 110 Gigabits/year. The volume required of auxiliary data, from Table 7.1, is approximately one quarter that of the space data.

From Figure 7.1, OSTA's program is devoted to research efforts through approximately 1986. Table 7.2 shows that the corresponding acceptable time lapse of data delivery is of order two to four weeks.

Figure 7.1 shows for the post-1986 time frame a gradual transition from R&D to technology transfer activities. These latter could acquire two forms: 1) algorithms and models developed by NASA researchers are tested by other federal agencies upon their facilities, in this case NOAA's; or 2) they are tested on NASA facilities with participation from sister agency personnel.

The first form of transfer does not impact ADS because by current definition, ADS is intended to service NASA researchers only. In the second event, the timeliness requirements for data transfer would be of order six hours.

Thus, during the time frame in which the research mode predominates, approximately through 1986, ADS data transfer requirements can be satisfied by a service of data rate comparable to that of the U.S. mail.

TABLE 7.1

USER REQUIREMENTS FOR AUX LIARY DATA PRODUCTS, GLOBAL WEATHER DISCIPLINE

TYPE OF DATA	DATA PRODUCT FORMAT	SOURCE	ESTIMATED YEARLY PRODUCT VOLUME* GW 1	GW 2	GW 3	GW 4	TOTAL	USE OF DATA PRODUCT
Land Surface Meteorologic observations (Surface Observations from WWW Synoptic Data Stations)	Digital 800 BPI tape of Wind Temperature, Humidity and Pressure Data	EDIS (NCC, NMC)	12	9	15	24	60	Calibration & verification of data from HIRS, VTPR, VISSR, SMMR Correlation with satellite data at 6-hour intervals to multilevel meteorologic models such as the GLAS general circulation model
Upper Air Meteorologic Observations (Rawinsonde Observations)	Digital 800 BPI Tape of Wind, Air Temperature and Humidity at 33, 50 mb pressure levels	EDIS (NCC)	12	7	15	24	60	Calibration & verification of satellite atmospheric sounder data Correlation with satellite sounder data to improve vertical resolution for input to multilevel meteorologic data
Surface rain occurrence/ rate data (Conventional Weather Radar Data)	Digital, high density, calibrated, radar echo intensity tape	EDIS (NSSFC, NSSL)	-	-	300	-	300	Radar data remapped to conform to satellite coordinates are used to calibrate satellite rain rate measurements on AIOPS
Sea Surface meteorologic oceanographic data (Data Buoy Data)	Monthly Regional digital 800 BPI data buoy summary tape of sea surface wind, air temperature, sea surface temperature	EDIS (NODC, NOAA/DBO)	4	3	-	8	15	Calibration and verification of satellite data over ocean areas
Synthesized Meteorologic Data	Digital 800 BPI tape of gridded 10 level multisource wind, temperature and humidity analysis data	EDIS (NMC) FNWC AFGWC	-	-	-	2	2	Comparison and verification of numerical forecast results generated by satellite based multilevel meteorologic models (GISS, GCM & GLAS GCM)
Sea surface meteorologic/ oceanographic data (Ship & Ocean Station Data)	Monthly microfilm summary of wind, air temperature, and sea surface temperatures recorded by ship and fixed ocean stations	EDIS (NCC, NODC)	4	3	-	8	15	Calibration and verification of satellite data over ocean areas

*Volume specified in number of individual products (Tapes, maps, reports....)

TABLE 7.2

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: GLOBAL WEATHER (OBSERVATIONS)

	R&D ACTIVITY			
	ATMOSPHERIC THERMAL BALANCE ASSESSMENT	ATMOSPHERIC CONVECTIVE BALANCE ASSESSMENT	ATMOSPHERIC WATER BALANCE ASSESSMENT	INTEGRATED GLOBAL WEATHER MODELING
REQUIREMENTS	GW 1	GW 2	GW 3	GW 4
Horizontal Resolution (KM)				
Minimum	25	100	25	50
Maximum	500	500	500	500
Modal	100-500	100-500	500	500
Vertical Resolution (KM)				
Minimum	1	0.5	1	0.5
Maximum	5	20	50	10
Modal	1	0.5-20	2-4	5
Frequency				
Minimum	1 Day	6 Hrs.	6 Hrs.	6 Hrs.
Maximum	6 Hrs.	6 Hrs.	6 Hrs.	6 Hrs.
Modal	6 Hrs.	6.Hrs.	6 Hrs.	6 Hrs.
Data Delivery				
Research Investigations	2-4 Weeks	2-4 Weeks	2-4 Weeks	2-4 Weeks
Technology Transfer	Realtime	Realtime	Realtime	Realtime

TABLE 7.2 (Cont'd)

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: GLOBAL WEATHER (SPECIAL SERVICES)

REQUIREMENTS	R & D ACTIVITY			
	GW 1	GW 2	GW 3	GW 4
Provide the capability for Investigators to perform interactive data processing on centralized data service computer via remote terminal	X	X	X	X
Format Auxiliary Data Into A Computer Compatible Form	X	X		X
Provide Satellite data mini tapes to investigators for requested geographic locations and times	X	X	X	X
Digitize and format radar data to conform to satellite coordinates			X	
Format Satellite & Radar Data for Use on AOIPS			X	
Locate and Provide Satellite and Auxiliary data corresponding to requested geographic locations		X		
Comprehensive Quality Control of meteorologic data sets formed from multiple sources need to be established & maintained for use in evaluating models				X

TABLE 7.2 (Cont'd)

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: GLOBAL WEATHER (STANDARD ALGORITHMS)

REQUIREMENTS	R & D ACTIVITY GW 1	GW 2	GW 3	GW 4
Temperature Profiles	X	X	X	X
Humidity Profiles	X	X	X	X
Cloud Extent (Cover)	X		X	X
Cloud Levels & Thickness	X		X	
Surface Wind Speeds	X			
Aerosol Turbidity	X			
Surface Temperature	X			X
Wind Profiles		X		X
Cloud Top Particle Size			X	
Cloud Top Particle Thermo-dynamic Phase			X	
Rain Rate			X	X
Snow & Ice Cover				X
Improved Boundary Layer Models				X

It is only in the latter part of the decade that the need for links becomes more stringent; and then only in the hypothesis that a substantial amount of technology transfer be performed employing NASA facilities.

The slow data delivery requirements of the early time frame do not necessarily connote that electronic linkages are not desirable. They simply indicate that the choice of the link is driven by economic cost-effectiveness rather than by technical urgency. For example, a plausible ADS scenario may well incorporate a centralized accounting, scheduling and data traffic monitoring facility; which maintains track of expenditures on the part of the users, supplies them budgetary estimates, advises them of impending depletion of project funds. Further analysis might reveal that such centralized management function can be performed more cost-effectively through use of electronic data links than through other conventional alternatives; quite apart from considerations of speed.

As a gross sizing of the "electronic link" alternative during the "slow" R&D time frame, the corresponding transfer requirements are such as to engage the equivalent of approximately 8 data links of 1,200 bps capacity each, operating on a one shift, normal work week basis.

Because the driver is economics, not technology, system tradeoffs can exploit to the fullest special tariff structures and price breaks: e.g. discounts for off-time operation, quantity savings from use of bulk bandwidths, use of satellite links whenever transfer distance exceeds the cost breakpoint (currently of order 900 kilometers).

Analysis of Table 7.3 permits the further inference that user services related to imagery manipulation---e.g. geocoding, superposition of formats, gridding---will not impose significant technological requirements upon ADS. This is because relatively large spatial resolutions are adequate to satisfy the users.

Users need to have available approximately 12 significant algorithms, Table 7.2. A potential evolutionary trend in the latter part of the 1980-1990 decade is the transition from user-peculiar development of these algorithms to their routine use--after the necessary confidence resulting from high "batting averages" will have been achieved.

Such an evolutionary development would open the ADS to the opportunity of providing a centralized algorithm processing function. Algorithms which reach fruition would be transferred to this function for conventional processing: the Researcher would retain the function of developing the newer generations of algorithms.

In summary, the Global Weather Discipline imposes upon ADS:

- Lenient requirements as to link speeds, as long as NASA user efforts remain in the R&D mode.
- Significant requirements if NASA users transition to the technology transfer mode performed on NASA facilities. This is not likely to occur until 1986 at the earliest.
- Moderate requirements of technological sophistication of user services, in all modes - R&D and Technology Transfer.
- Option of incorporating the function of algorithm processing.

TABLE 7.3

DATA SERVICE REQUIREMENTS FOR THE GLOBAL WEATHER DISCIPLINE

		ATMOSPHERIC THERMAL BALANCE ASSESSMENT	ATMOSPHERIC CONVECTIVE BALANCE ASSESSMENT	ATMOSPHERIC WATER BALANCE ASSESSMENT	INTEGRATED GLOBAL WEATHER MODELING
DATA LOCATION	Data Catalog	■	■	■	■
	Data Dictionary	■	■	■	■
	Computer Search				
DATA EDITING	Quality Control				
	Data Sorting	●	●	●	
REFORMATTING	Form Conversion			■	
	Code Conversion				
	Coordinate Conversion			■	
	Scale Conversion				
ASSEMBLY	Data Segment Preparation	●	●	●	
	Data Set Preparation	●	●	●	●
DATA INTEGRATION	Single-Source Multi-temporal Data Registration				
	Single-Source Multi-temporal Data Merging				
	Multi-Source Uni-temporal Data Registration		●	●	
	Multi-Source Uni-temporal Data Merging	●		●	●
	Data Gridding	●	●	●	●
	Data Overlay		●		
	Image Mosaicing				
SPECIAL PROCESSING	Radiometric Correction	●	●	●	●
	Geometric Correction				
	Other				
DATA MGM'T	Data Archiving				
	Data Delivery	1	1	1	1
OTHER					

■ High Value Data Service ● Desirable Data Service

Note 1: Near Real Time for Tech. Transfer

7.3 Implications of ADS on the Global Weather Discipline

The consensus of the users in the Global Weather Discipline focuses upon the following key data-related points:

- Users obtain most of their space and auxiliary data from NOAA/NESS and the NCC Satellite Data Services Branch. Typically, these deliver two months after order. Delivery from other data bases require from one to three months.

  Thus, current time lapses from ordering to acquisition of data range from one to three months.

  The bulk of current users engages in research efforts: they are, in theory, not affected by data delivery times. In practice, the long wait slows down the pace of their efforts, thus the *efficiency of the R&D effort.*

  The timing with which the users feel "comfortable" is two to four weeks, Table 7.2, instead of the one to three months currently experienced.

- A relatively small group of users is engaged in pre-operational demonstrations, e.g., the Global Weather Experiment.

  These researchers indicate that delivery times of order two weeks are needed to permit flagging data deficiencies, e.g., poor product quality or misplaced observation site, in order to perform timely amendments within a time useful to affect their project.

  Another cogent observation by these users, although perhaps transcending ADS's current design bounds, is that real-time operational control of data during special observation periods would be highly desirable.

- The majority of researchers indicate that even though the cost of individual data products is nominal, the deficiencies of the current data delivery system seriously impact their budgets. Their choices lie between ordering an excess of data products from which to glean the good samples, or devote excessive time to preselection of the products to be ordered so as to minimize the probability of receiving flawed data. Their primary mode of operation is the latter: in either event, current modes of data delivery seriously impact their budgets.

  To remedy this problem, *the most important ADS function identified by Global Weather users is the maintenance of a comprehensive, continuously updated catalog identifying not only location and general content of the data, but additionally providing indications as to the quality of each datum.*

  In other words, the users want a data directory augmented by a running, rapidly available log of the pertinence and quality characteristics of *individual data.*

- The users cannot exploit all the pertinent sources of auxiliary data of which they have knowledge, due to two principal reasons: the financial constraints aforesaid, and the time required to reformat the auxiliary data to match the format of the space-derived data.

  An example offered by users relates to ground radar data, used to calibrate satellite rain measurements. A limited amount of radar data is currently available in digital format: virtually all must be subjected to appropriate geocoding transformations against satellite data. Thus, most of the available analog radar data is not currently being used.

- Global Weather users experience significant handicaps as regards the combination of data. For example, researchers involved in global precipitation mapping indicate that one-third of their time is spent on reformatting and geocoding, mostly still accomplished manually. The provision of low-cost geocoding and reformatting services---whether centralized or individual--would be highly desirable, provided that their quality and reliability match that of currently employed non-automatic methods.

In summary, the principal impact of an ADS upon the users of the Global Weather Discipline would be economic, i.e. a significant reduction of researcher time, possibly as much as a factor of two. Improvement of the quality of research would probably also result from relieving researchers from much of the "drudgery" currently involved in their labors.

Three key functions would promote increased efficiency. In approximate priority:

- Provision of a data directory and concurrent running data log
- Provision of efficient methods of combining data
- Acceleration of data delivery times by a factor of two to four. Note however that most of the delay currently experienced is caused by the internal reaction time of the data bases: thus the simple provision of faster data transfer links would in this case not suffice. More sophisticated strategies would need to be employed.

8.1 Description of Objectives and Content

The responsibility for ocean-oriented activities is primarily distributed among three Federal Agencies. Each is charged with varying charters in pursuit of its own specialized field of operational or research endeavors.

Principal Agency interests are:

- NOAA -- Ocean Research in general; operational responsibility for gathering environmental oceanic-related data in support of U.S. private activities, particularly fishing, seabottom resource extraction.
- Coast Guard--protection of U.S. maritime interests within U.S. Coastal waters.
- U.S. Navy--performs a substantial body of research, some of whose spinoffs are of major interest to civilian oceanic scientists. It also cooperates with NOAA on specific oceanic programs.

In addition, private U.S. industry engages in oceanic operational activities, and performs significant oceanic research, e.g. technologies for ship navigation and safety, improved ship design, seabottom exploitation techniques.

The operational activities of the private U.S. fishing fleet are well known.

Because of the recent interest in the Coastal Zone--extended in 1975 from 12 to 200 miles - and in the fuel deposits beneath arctic waters, there are overlaps between the disciplines of Ocean Processes and those of Coastal Zone and Cryosphere. What follows therefore addresses the core interests of the ocean community, beyond coastal zone and ice-covered waters.

The oceans cover approximately 70% of the earth. The principal factor determining the structure of the oceans and their effect upon the environment is circulation. Water movement is driven by two principal factors; wind and differences of density.

Winds are the key drivers of ocean surface circulation. They transfer momentum to the upper ocean layer through fluid friction. The effectiveness of the momentum transfer depends upon the ocean surface's roughness.

The circulation of the low oceanic waters is driven primarily by mechanisms causing density differences in these layers. Interaction of the ocean's surface with the atmosphere induce changes in temperature and salinity. Temperature increases from absorption of the sun's radiant energy and decreases through evaporation and conduction of heat to the atmosphere. Salinity is increased by evaporation and surface water freezing and is reduced by fresh water influx from precipitation, land surface runoff, and melting ice. The circulation results from convection currents which arise in the attempt to balance the resultant density differences.

Ocean currents and related processes impact weather and climate; the oceans transport toward the poles approximately half of the excess heat deposited in the tropics. Development of the capability to predict climate requires establishing methods of monitoring the heat storage and stability of the oceans and the exchange of properties between the atmosphere and the oceans.

Ocean circulation processes are important to life within the marine environment. They serve to replenish the supply of oxygen and nutrients and aid the dispersal of detrimental wastes. Currents transport and distribute planktonic organisms which serve as the primary source of food for larger marine organisms.

Oceanographic users need to monitor and predict the state of the ocean and the interactions between the ocean surface and the overlaying atmosphere. Prediction capability requires improved understanding of the processes responsible for such variability, and availability of a data base sufficient to operate and rigorously evaluate models developed.

Remote sensing techniques were first applied by ESSA and NASA to ocean-related problems in the early 1960's with TIROS-1. Information derived from visible and IR signatures has had impact on the study of large current systems and of the global heat balance. TIROS was followed by ITOS, NIMBUS, ESSA, ATS, NOAA, SMS, and GOES, all of which make some form of surface temperature measurement using infrared and microwave radiometry.

The initial success of radiometry encouraged the use of radar techniques. Skylab successfully demonstrated in 1973 scatterometry and altimetry as practical spacecraft techniques for measuring ocean surface wind, sea state and current speed.

Data from GEOS-3 altimetry has shown that "significant wave height" can be determined within ±15%. These data generate ocean surface topographic maps which can be used to calculate the surface velocity of the major current systems, such as the Gulf Stream and Kuroshio, within ± 20 cm/sec.

A new generation of aircraft radar altimeter developed by NASA has obtained sea state measurements accurate to ± 10% of the "significant wave height" and profiling precisions from 2 to 10 cm, making it possible to measure the surface wind vector field within 2 m/s or ±25% in magnitude up to 25 m/sec and $\pm 20^{0}$ in direction from that of the aircraft.

The objective of OSTA's Ocean Processes Discipline Program is to develop and improve the capability to remotely observe the ocean from space, to serve the ocean user community in optimally exploiting such observations to satisfy their own and then customer's needs.

The current research emphasis of OSTA's Ocean Processes discipline program is to provide support to the investigation of the mechanisms driving global ocean circulation processes. The current operationally oriented emphasis is towards utilizing wind and wave measurements to support ship routing and operations scheduling. OSTA Ocean Processes Discipline joint research projects with universities and commercial ocean research organizations are geared to the definition of operational and research requirements and to provide improved algorithms for converting remote sensing data into geophysical information.

Current OSTA Program

OSTA's efforts comprising the Ocean Processes Discipline Programs fall into five categories of R&D Activities:

OP 1 Wind-Wave Interaction

Development of techniques to assess the transfer of momentum between atmosphere and ocean surface. They are based on combinations of inferential derivations:

Sea surface wind, surface wind shear and surface layer transfer; from measures of ocean surface roughness;

Wave height distribution: from the noise spectra in altimetry-range measurements;

Wave length spectra: from high resolution images of the ocean surface;

Wind vector and wind shear: from variations in radar backscatter coefficient and from microwave images of surface foam effects on brightness temperature;

Wave height distributions: from the shape of a narrow pulse radar return pulse;

Wave length distributions: from radar images of the surface with resolutions of 100 meters or less.

The significance of these techniques is that wind shear causes layer motion: this moves fish larva and oil spills around, causes storm tides and subsequent upwelling, and develops gravity waves (swell) which can provide hazards for ships and limit ocean operations. Wind/wave interaction is important to ship routing, ship operations scheduling, ship design, resource exploration, sea state and current forecasts, iceberg forecasts, resource and pollution management.

OP 2 Global Ocean Circulation

Development of techniques and algorithms to assess and measure the ocean circulation and mass transfer. The areal distribution of ocean currents, eddies, upwelling and thermal fronts are indicated by variations of color and temperature from passive visible, infrared and microwave images; and from variations of surface roughness in radar images. Current speeds are inferred from ocean color, surface temperature or roughness gradients, from time series images of recognizable moving features, and from the Coriolis bulges generated by geostrophic currents. The measurement of Coriolis bulges from doppler shift awaits the development of high resolution laser scanners projected for the future.

The significance of these techniques is that ocean circulation on a global scale affects weather and climate in a major way. Coupling between ocean eddies and atmospheric circulations; changes in rainfall and sea ice coverage affected by currents, has been demonstrated. On a local scale, currents affect ship routing, and move fish larva and pollutants about.

OP 3 Marine Geology and Surface Topography

Development of techniques and algorithms for measuring the marine geoid and its periodicity due to pressures, tides, winds, currents, and waves. Ocean surface topography is measured from radar or laser ranging. Time variations and ranging noise are utilized to separate the effects of waves, pressure, tides, and currents.

The importance is that accurate knowledge of the marine geoid is important to spacecraft navigation and ballistic targetting. Understanding the noise in the equipotential gravity surface contributes to the understanding of weather, sea state, tidal excursions, and current motions.

OP 4 Ocean Biology

Research into techniques and algorithms for measuring and assessing oceanic biological and chemical processes. Oceanic bio-growth is related to temperature; to nutrient, salinity, dissolved gases and turbidity patterns; it is negatively affected by pollutants. Ocean biological growth may be inferred from chlorophyll, phytoplankton and zooplankton concentrations which have recognizable absorptions in specific high resolution spectral bands.

Biological growth patterns are important in locating and maintaining marine fish resources. Chemical pollutants affect this biological balance and are transported to coastal ecologies where they engender even greater effects.

The ocean acts as a carbon dioxide sink in a complex manner; it modulates climatic effects due to CO_2 increases.

OP 5 Impact on Weather and Climate

Research and Development of techniques and of algorithms for measuring and assessing the thermal, water and momentum exchange with the ocean surface atmosphere. Surface air, sea surface and ocean subsurface temperature contribute to the global radiation balance and water cycle processes. Sea surface temperature measurements are achievable with present infrared and microwave radiometers. Surface air temperatures are potentially derivable from an IR radiometer with a wave number of 0.01 (not presently achievable). Subsurface ocean temperature measurements have been demonstrated to a very limited extent using active lasers. Dissolved CO_2 measurements are conceptually possible but have not yet been practically implemented.

Developing the capability to predict climate will require establishing methods of monitoring the heat storage and stability of the oceans and the exchange of properties between the atmosphere and the oceans.

Near Future OSTA Program

The research elements of OSTA's near term Ocean Processes program are:

- Extraction of ocean surface topography from satellite altimetry
- Measurement of atmospheric and surface reflection of the ocean
- Development of ice environment information products
- Measurement of SAR point targets
- Development of improved spatial resolution of passive microwave images

The technology elements of OSTA's near term Ocean Processes program are:

- Development of EM techniques for assessing wave-ocean surface interaction
- Design for an advanced altimeter for subsurface profiling of glacial ice
- Demonstration of the applications of remote sensing to open ocean fisheries environment modeling and prediction
- Development of improved spatial resolution of passive microwave images

Future OSTA Program

The goals are to design, develop and demonstrate improved capabilities to acquire and process global satellite observations of oceanic parameters to determine:

- The general circulation and mesoscale variability of the ocean
- The mechanisms of generation and persistence of surface waves and currents by the winds
- The flux of mass, momentum, and heat between the upper ocean and the atmosphere.
- Reliable indicators of the presence and productivity of marine life, e.g. chlorophyll, phytoplankton.

Figure 8.1 presents a graphic synopsis of OSTA's Ocean Processes Program.

The first portion of the Figure reflects the space missions, current and projected, whose data products support the Program. The subsequent portion and continuation sheets reflects the Program's endeavors for each identified R&D Activity.

Each element is referenced to its pertinent source documents; their titles are listed at the Figure's end.

8.2 Relationships between Data Services and the Ocean Processes Discipline

Figure 8.2 summarizes the requirements for data products expressed by the users.

FIGURE 8.1

OCEAN PROCESSES DISCIPLINE TIMELINE

OSTA MISSIONS

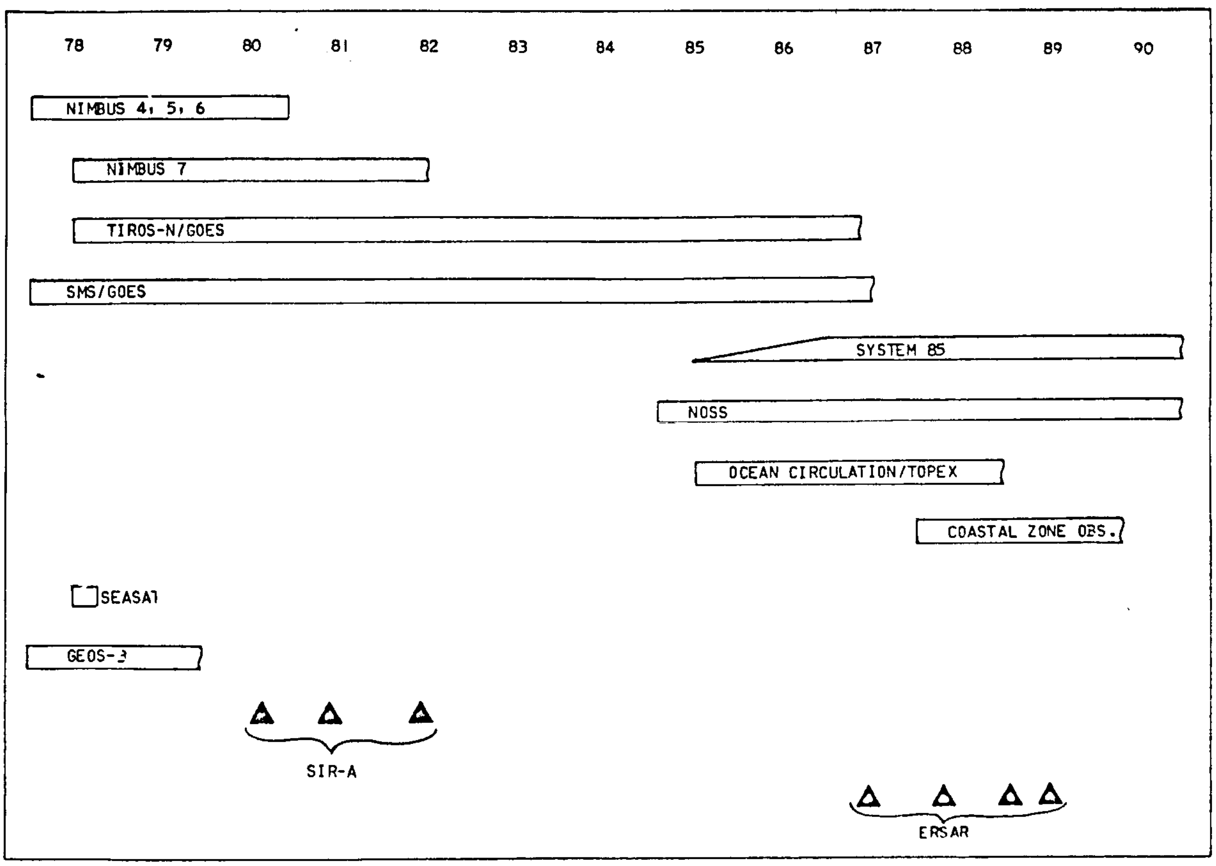
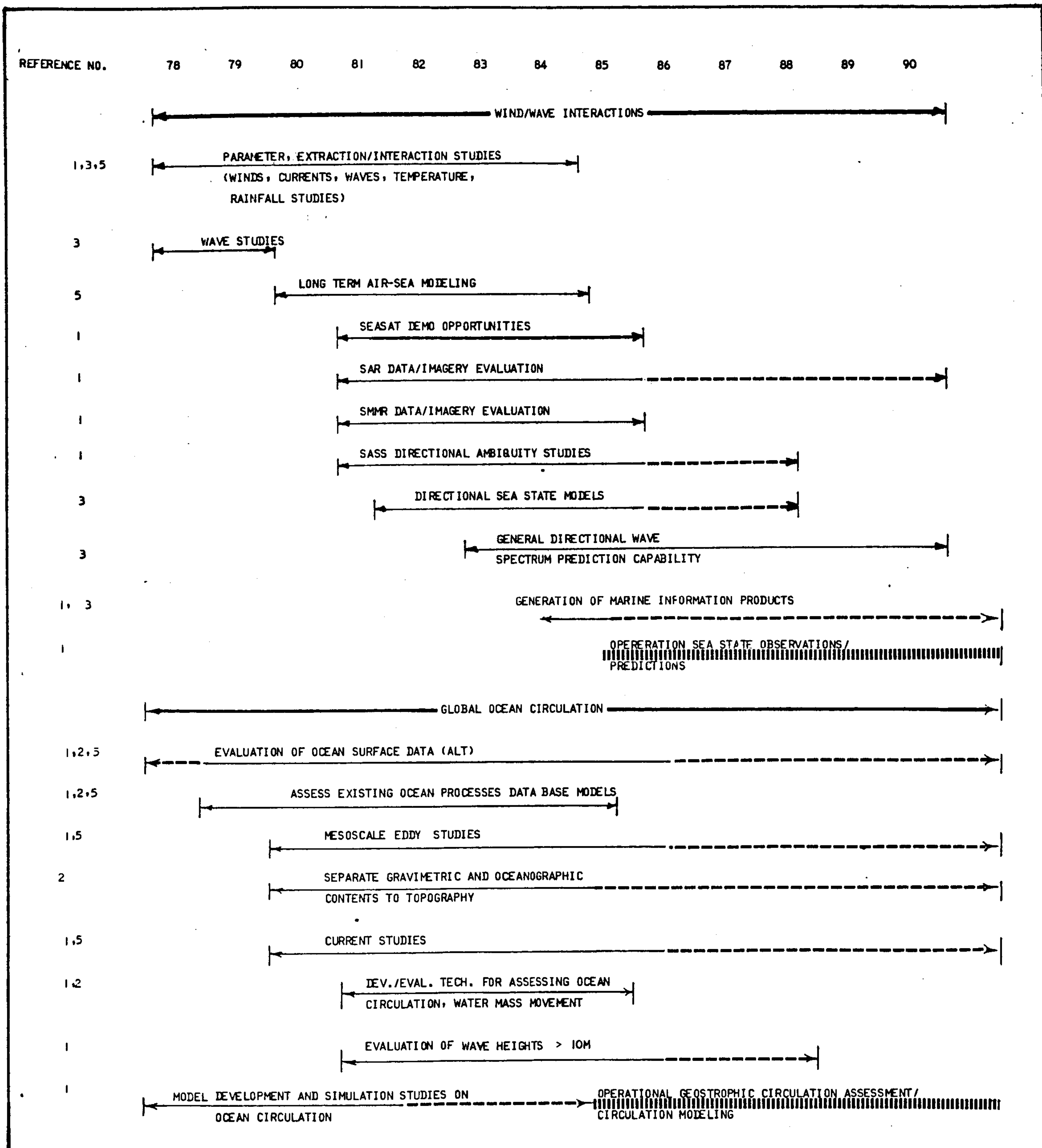


FIGURE 8.1

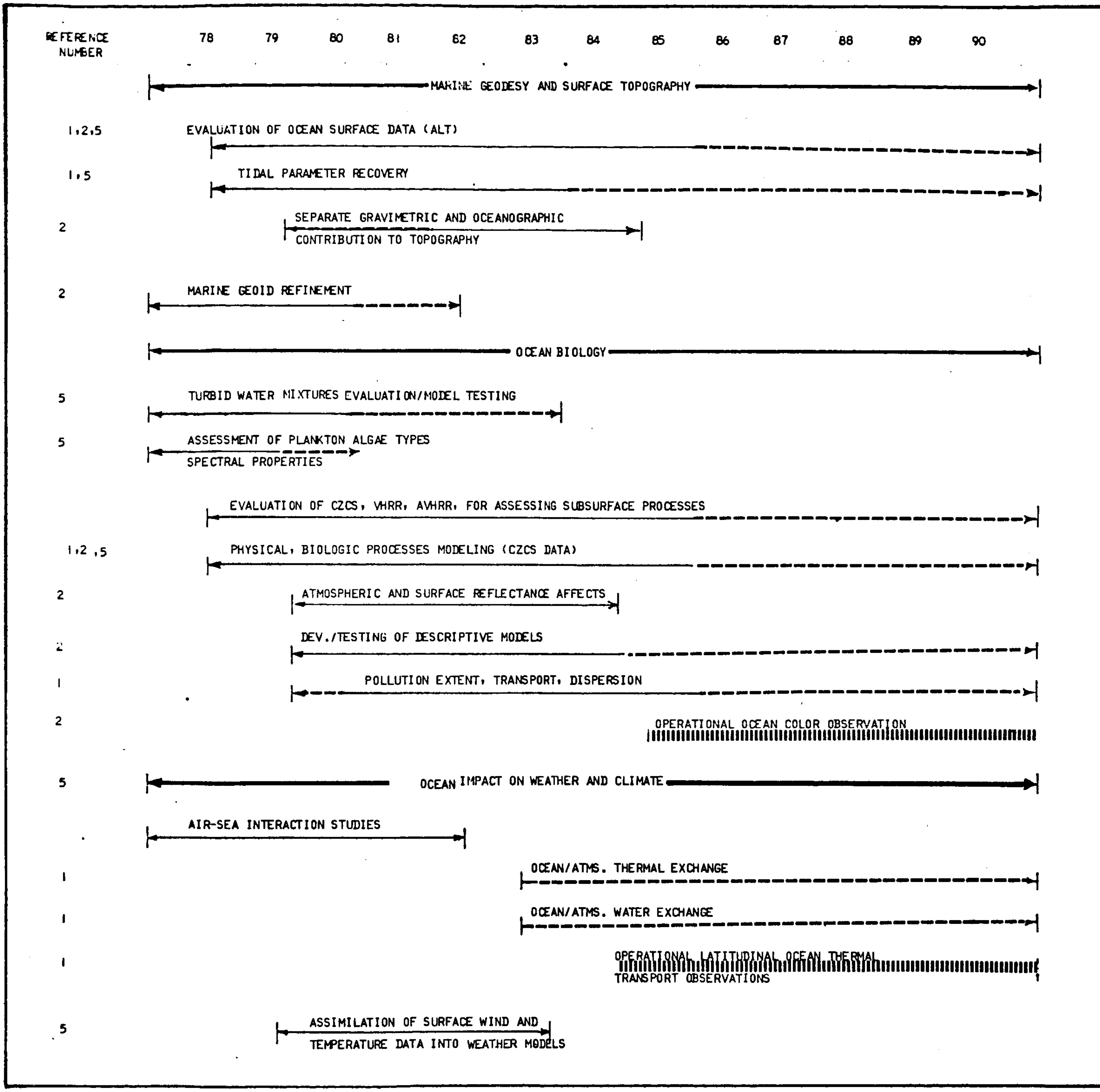
OCEAN PROCESSES DISCIPLINE TIMELINE

R & D ACTIVITIES



OCEAN PROCESSES DISCIPLINE TIMELINE (CONT'D)

R & D ACTIVITIES



REFERENCES: (1) ENV. OBS. DIVISION 5-YR. PLAN: FY 81-85 TO NASA PLANNING COUNCIL, 1979
(2) OCEAN PROCESSES PROGRAMS 5-YR. PLAN
(3) OCEANOLOGY SUBPROGRAM PLANS, 1977
(4) RES. OBS. 5-YR. PLAN: FY 81-85 PRESENTATION TO NASA PLANNING COUNCIL, 1979
(5) RTOPS 79 & 80

LEGEND

1 Flight Mission
2 Program Emphasis
3 R&D Activity
4 Continuing Activity
5 Technology Transfer (Pilot/Application Tests Etc.)
6 Short Term Event
7 Initial Operational Capability
8 All Investigation Classes

FIGURE 8.2

USER REQUIREMENTS FOR SPACE DATA PRODUCTS, OCEAN PROCESSES DISCIPLINE

		NIMBUS 5	SEASAT A					NIMBUS 7		GOES	DMSP BLOCK 5	GOES	TIROS N	DMSP BLOCK 6	SHUTTLE	NOSS				TOPEX	SYSTEM 85		SHUTTLE	COASTSAT	
PARAMETERS		ESMR	SMMR	SASS	VIR	SAR	ALT	SMMR	CZCS	ALT	OLS	VISSR	AVHRR	OLS	SIR	LAMMR	SCAT	CZCS	ALT	ALT	VISSR FOLLOW	AVHRR FOLLOW	ERSAR	COLORI-METER	
WAVE HEIGHT							●			●									●	●					
WAVE LENGTH						●									●								●		
WAVE DIRECTION						●									●								●		
SURFACE WATER ROUGHNESS				●				●									●								
SURFACE WIND SPEED			●	●			●									●	●								
SEA SURFACE HEIGHT										●									●	●					
SEA SURFACE TEMPERATURE		●	●		●			●			●	●	●	●		●					●	●			
MULTISPECTRAL REFLECTANCE (WATER COLOR)									●									●						●	
AIR TEMPERATURE PROFILE																									
PRECIPITATION RATE			●					●			●			●		●									
DATA BANKS																									
NOAA/NESS			●	●	●	●	●					●	●								●	●			
NCC/SDS												●	●								●	●			
GSFC/IPD		●						●	●																
JPL/SEASAT CDHF			●	●	●	●	●																		
NSSDC		●						●	●	●					●					●			●	●	
FNWC											●		●												
NOSS/PPD																●	●	●	●						
EROS															●								●		
PRODUCTS																									**PRODUCT TOTALS**
1980	TAPES/YR.	210	6	432	10	460	555	236	20	555	20	455	-	-	-	-	-	-	-	-	-	-	-	-	2984
	IMAGES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OTHERS/YR.	-	-	-	-	30 FS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30 FS
	G BITS/YR.	7	0.2	15	0.4	16	19	8	0.7	19	0.7	1	16	-	-	-	-	-	-	-	-	-	-	-	104
1985	TAPES/YR.	-	-	-	-	-	-	-	-	-	-	23	438	5	460	432	432	40	819	819	23	18	-	-	3509
	IMAGES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	20FS	-	-	-	-	-	-	-	-	-	20 FS
	G BITS/YR.	-	-	-	-	-	-	-	-	-	-	1	16	0.2	16	15	15	1	29	1	-	-	-	-	123
1990	TAPES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	5	-	432	432	10	1434	1014	25	455	460	20	4287
	IMAGES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
	OTHBRS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20FS	-	20 FS
	G BITS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	0.2	-	15	15	0.4	50	36	1	16	16	1	150

Users are interested in obtaining parameters. These are intermediate information products derived from sensor measurements, elaborated via the application of appropriate algorithms. For example, sea surface temperature information derives from remotely sensed radiance data elaborated in conjunction with surface emissivity, atmospheric absorption, sensor calibration data.

At this time, NASA users in the Ocean Processes Discipline are in the process of developing such algorithms. For this purpose, they wish to receive raw space data, augmented by the auxiliary data summarized in Table 8.1.

The volume of required space data shows a moderate increase through the 1980-1990 decade, from approximately 100 to 150 Gigabits/year. The volume required of auxiliary data, from Table 8.1, is less than one tenth that of the space data.

From Figure 8.1, OSTA's program focuses on research efforts through approximately 1985. Table 8.2 shows that the corresponding acceptable time lapse of data delivery is of order four weeks.

Figure 8.1 shows for the post-1985 time frame transition from R&D to technology transfer activities. These latter could acquire two forms: 1) algorithms and models developed by NASA researchers are tested by other federal agencies upon their facilities, in this case NOAA's; 2) they are tested on NASA facilities with participation from sister agency personnel.

TABLE 8.1

USER REQUIREMENTS FOR AUXILIARY DATA PRODUCTS, OCEAN PROCESSES DISCIPLINE

TYPE OF DATA	DATA PRODUCT FORMAT	SOURCE	ESTIMATED YEARLY PRODUCT VOLUME* OP 1	OP 2	OP 3	OP 4	OP 5	TOTAL	USE OF DATA PRODUCT
Data Buoy	Monthly regional digital (800 BPI) data buoy summary tape of sea surface wind, air temperature and sea surface temperature, surface currents and wave spectra	EDIS (NODC, NOAA/DBO)	6	7	-	1	5	19	Calibration and verification of satellite derived oceanographic data
NANSEN CAST Data	High density digital tape (1600 BPI) of STD data down to 11,999 m	EDIS (NODC)	-	7	-	1	5	13	Calibration and verification of satellite derived oceanographic data
Expendable Bathythermograph Data	Low density digital (800 BPI) tape of ocean temperature data from 0 to 1850 m	EDIS (NODC)	-	7	-	1	5	13	Calibration and verification of satellite derived oceanographic data
Drift Bottle Data	Low density (800 BPI) digital tape of surface and seabed current data	EDIS (NODC)	6	7	-	-	5	18	Verification of satellite-based ocean circulation model results
Synoptic Ocean Meteorologic Observations	7 channel (556 BPI) digital tape of surface and upper air meteorologic data (wind, sea surface temperature, sea state air temperature, air pressure and humidity) for all available Northern hemisphere ship and fixed stations (≈9 days data per tape)	EDIS (NCC, NODC, NMC, NMFS)	24	28	-	-	70	122	Verification and calibration of satellite data for input to coupled ocean-atmosphere circulation models.
Ocean Biological & Chemical Species Data	Microfilmed research cruise record summary data (water sample analysis and plankton net analysis)	EDIS (NODC) SCRIPPS WHOI NMFS	-	-	-	1	-	1	Correlation with water color for correction and verification of biological species and pollutant classification schemes

*Volume specified in number of individual products (Tapes, maps, reports....)

TABLE 8.2

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: OCEAN PROCESSES

(OBSERVATIONS)

	R & D ACTIVITY				
	WIND WAVE INTERACTIONS	GLOBAL OCEAN CIRCULATION	MARINE GEODESY & SURFACE TOPOGRAPHY	OCEAN BIOLOGY	IMPACT ON WEATHER AND CLIMATE
REQUIREMENTS	OP 1	OP 2	OP 3	OP 4	OP 5
Horizontal Resolution (KM)					
Minimum	0.02	0.1	0.05	0.1	200
Maximum	10	500	0.1	10	500
Modal	0.02-0.1	500	0.05-0.1	0.1-10	500
Vertical Resolution (KM)					
Minimum	N.A.	N.A.	N.A.	N.A.	0.2
Maximum	N.A.	N.A.	N.A.	N.A.	10
Modal	N.A.	N.A.	N.A.	N.A.	1
Frequency					
Minimum	12 Hrs.	1 Day	12 Hrs.	1 Day	5 Days
Maximum	2.4 Hrs.	2.4 Hrs.	2.4 Hrs.	1 Day	1 Day
Modal	2.4-12 Hrs.	1 Day	2.4-12 Hrs	1 Day	1 Day
Data Delivery					
Research Investigations	4 Weeks	4 Weeks	4 Weeks	4 Weeks	4 Weeks
Technology Transfer	2-24 Hrs.	3-24 Hrs.	3-24 Hrs.	3-24 Hrs.	N.A.

TABLE 8.2 (cont'd)

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: OCEAN PROCESSES

(SPECIAL SERVICES)

	R & D ACTIVITY				
REQUIREMENTS	OP 1	OP 2	OP 3	OP 4	OP 5
Provide Satellite Data Mini-tapes for Requested Geographic Locations and Time Periods	X	X			
Provide Auxiliary Data In A Computer Compatible Format	X				
Provide the Capability for Investigators to Perform Interactive Data Processing On a Central Data Service Computer Via Remote Terminal	X	X			
Provide a Multisource Data Collection and Editing Service		X			
Provide Catalog and Dictionary Services for Auxiliary Data		X			
Provide Sea Surface Topography Maps			X		
Precision Radiometric Calibration of Satellite Data Products				X	
Digitize & Format Radar Data to Conform to SMMR Geographic Coordinates					X

TABLE 8.2 (cont'd)

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: OCEAN PROCESSES (STANDARD ALGORITHMS)

REQUIREMENTS	R & D ACTIVITY OP 1	OP 2	OP 3	OP 4	OP 5
Sea Surface Wind Shear	X				
Sea State Index	X				
Ocean Temperature Profiles		X		X	
Geostrophic Flows from Ocean Topography		X			
Eckman Depth and Flow Derived From Remote Measurement of Surface Wind Speed, Direction & Sea Surface Roughness		X			
Location of Upwelling Derived from Ocean Color & Temperature Fields		X			
Ocean Tide Models			X		
Ocean Geoid Models			X		
Algae & Plankton Distribution				X	
Ocean Salinity				X	
Improved Ocean Heat Balance Models					X
Improved Ocean Circulation Models					X

The first form of transfer does not impact ADS because by current definition, ADS is intended to service NASA researchers only. In the second event, the timeliness requirements for data transfer would be of order six hours.

Thus, for research efforts, except for technology feasibility demonstrations, ADS data transfer requirements can be satisfied by a service of data rate comparable to that of the U.S. mail.

In the latter part of the decade the need for links becomes more stringent; and then only in the hypothesis that a substantial amount of technology transfer be performed employing NASA facilities.

The slow data delivery requirements of the early time frame do not necessarily connote that electronic linkages are not desirable. They simply indicate that the choice of the link is driven by economic cost-effectiveness rather than by technical urgency. For example, a plausible ADS scenario may well incorporate a centralized accounting, scheduling and data traffic monitoring facility; which maintains track of expenditures on the part of the users, supplies them budgetary estimates, advises them of impending depletion of project funds. Further analysis might reveal that such centralized management function can be performed more cost-effectively through use of electronic data links than through other conventional alternatives; quite apart from considerations of speed.

As a gross sizing of the "electronic link" alternative during the "slow" R&D time frame, the commensurate transfer requirements are such as to engage the equivalent of approximately 18 data links of 1,200 bps capacity each, operating on a one shift, normal work week basis.

Because the driver is economics, not technology, system tradeoffs can exploit to the fullest special tariff structures and price breaks: e.g. discounts for off-time operation, quantity savings from use of bulk bandwidths, use of satellite links whenever transfer distance exceeds the cost breakpoint (currently of order 900 kilometers).

Analysis of Tables 8.2 and 8.3 permits the further inference that a goodly portion of the user services related to imagery manipulation--e.g. geocoding, superposition of formats, gridding---will impose significant technological requirements upon ADS. This is because relatively higher spatial resolutions are required by the users in three out of five R&D activities.

Users need to have available approximately 12 types of significant algorithms, Table 8.2. A potential evolutionary trend in the latter part of the 1980-1990 decade is the transition from user-peculiar development of these algorithms to their routine use--after necessary confidence resulting from high "batting averages" will have been achieved.

Such an evolutionary development would open the ADS to the opportunity of providing a centralized algorithm processing function. Algorithms which reach fruition would be transferred to this function for conventional processing: the Researcher would retain the function of developing the newer generations of algorithms.

TABLE 8.3

DATA SERVICE REQUIREMENTS FOR THE OCEAN PROCESSES DISCIPLINE

		WIND/WAVE INTERACTION	GLOBAL OCEAN CIRCULATION	MARINE GEODESY & SURFACE TOPOGRAPHY	OCEAN BIOLOGY	IMPACT ON WEATHER & CLIMATE
DATA LOCATION	Data Catalog	■	■	■	■	■
	Data Dictionary	■	■	■	■	■
	Computer Search	●	●	●	●	●
DATA EDITING	Quality Control	■	■	■	■	■
	Data Sorting	●	●	●	●	●
REFORMATTING	Form Conversion	●	●	●		
	Code Conversion					
	Coordinate Conversion					●
	Scale Conversion					
ASSEMBLY	Data Segment Preparation	●	●		●	
	Data Set Preparation	●	●	●	●	●
DATA INTEGRATION	Single-Source Multi-temporal Data Registration					●
	Single-Source Multi-temporal Data Merging					
	Multi-Source Uni-temporal Data Registration	●	●	●	●	●
	Multi-Source Uni temporal Data Merging					
	Data Gridding	●	●	●	●	●
	Data Overlay					
	Image Mosaicing					
SPECIAL PROCESSING	Radiometric Correction	●	●	●	●	
	Geometric Correction	●	●	●	●	
	Other					
DATA MGM'T	Data Archiving					●
	Data Delivery	1 ■	1 ■	1 ■	1 ■	
OTHER		2 ■	2 ■	2 ■	2 ■	3 ■

■ High Value Data Service ● Desirable Data Service

Note 1: Real Time for Tech. Transfer
2: Comprehensive Data Documentation
3: Prepare Seasonal Summaries of Ocean Rainfall, Surface Temp., Winds

A significant difference between the data services pertaining to the Ocean Processes Discipline and those related to other disciplines is the fact that a large number of external users are interested in receiving archived ocean observation data. To this effect, plans for NOSS contemplate the eventual establishment of an appropriate data dissemination network, to serve civilian and DOD users. Although such a network is not within the purview of ADS as currently defined, its eventual relationship with ADS should be taken into account in future ADS development phases.

A more significant requirement is posed by the merging of auxiliary scalar-vector data among themselves and with the space data. The reason is that much of the auxiliary data is derived at diverse times and locations, some of which are not only scattered, but whose exact occurrences and geographic sitings are poorly known. Examples are Biological and Chemical Species data, Drift Bottle data, Table 8.1, summaries of ship's logs. Full exploitation of the value of these data requires that their timings and locations be somehow correlated. This may impose upon ADS the desideratum of a "data assimilation" service, i.e. a processing function designed to test the data's consistency and to reduce them to a uniform time-space reference.

8.3 Implications of ADS on the Ocean Processes Discipline

Analysis of the Ocean Processes Discipline user requirements yields the following key data-related points:

- Almost 25% of the Ocean Processes Discipline users are currently involved in technology demonstration projects such as the sea-state and ocean current assessment applied to open ocean ship routing. Technology demonstration programs typically require data turnaround time of 1-3 hours. Some users would be satisfied with 24-72 hours. Current capabilities are of the order of 1-2 months.

  Near real-time data delivery time is the key to successful performance by end-users, hence by technology transfer investigation: this requirement is currently met by one OSTA data system, e.g. SEASAT's.

- The current 1-2 month delivery time is considered sufficient by the approximately 75% of the engaged in research.

- Research users are impacted by cost considerations brought about by the deficiencies of the current data system, principal among which are:

  a) conventional sources of key auxiliary data do not provide updated or sufficiently documented data catalogs and directories;

  b) data quality is often questionable;

  c) adequate geocoding information is not provided in the catalogs for the key auxiliary data.

  For these reasons, users are forced to acquire "total cruise" data at excess cost and with concommitant time delays.

  Users generally desire a data directory augmented by a running, rapidly available log of the pertinence and quality characteristics of *individual data. Therefore, an important ADS function identified is the maintenance of a comprehensive, continuously updated catalog identifying not only location and general content of the data, but additionally providing indications as to the quality of each datum.*

- A comprehensive, updated Ocean Process data catalog and data directory would significantly benefit the ocean related ADS discipline users as well as the Global Weather and Climate users.

- Data costs are not a significant consideration to technology transfer users who generally do not deal with historic data.

- Data merging and reformatting represents a major requirement for Coastal Zone users engaged in both research and technology transfer. This is particularly true since most auxiliary data is not in digital format and is not generally amenable to optical overlay processes. Thus, many users forego using large amounts of auxiliary data; they opt for the smaller quantity of data already available in digital form, thus limiting the completeness and quality of the results.

In summary, the principal impact of an ADS upon the users of the Ocean Processes Discipline would be economic, i.e. a significant reduction of the time and expense required for acquiring data in usable formats.

Three key ADS functions would promote increased efficiency. In approximate priority:

- A comprehensive data directory and catalog of primary space and auxiliary data with concurrent running data log

- Cost effective data merging and reformatting services

- Acceleration of data delivery times to support technology demonstrations

9.1 Description of Objectives and Content

Overall civilian responsibility for the National Severe Storm Program resides within NOAA's National Weather Service (NWS). The program's stated goal is "to save lives and reduce property damage caused by severe storms."

NOAA is assisted in this task by the U.S. Air Force Global Weather Central (AFGWC) and by the Department of Transportation's Federal Aviation Administration (FAA). AFGWC and FAA have their own responsibility for forecasting and monitoring severe local storms within regions of interest and for their specialized ends. They provide NOAA observational and communication support.

NOAA Centers with primary responsibility for forecasting and monitoring severe storms are:

- The National Severe Storms Forecast Center (NSSFC)
- The National Meteorological Center (NMC) and its regional Weather Service Forecast Offices (WSFO) and local Weather Service Offices (WSO).
- The National Environmental Satellite Service (NESS), and its Environmental Data Service (EDS) and Satellite Field Service Stations (SFSS).

NESS operates meteorological satellite systems which provide coverage of selected portions of the U.S. during the severe storm season, primarily April, May and June.

Severe storms are local weather events that usually cover relatively small geographical areas or move in narrow paths and are of sufficient intensity to threaten life and property. The conventional definition includes tornadoes, funnel clouds, waterspouts, thunderstorm with winds in excess of 50 knots and/or hail exceeding 3/4" in diameter at the surface.

Current operational techniques of forecasting and monitoring consist primarily in "spotting" their presence and providing the best possible prediction of track, and the fastest and most widespread public warning achievable.

The principal object of current research efforts is to predict the severe storm's formation prior to their occurrence. The major technological trend is shortening the time lapse between first inkling and effective public warning.

NOAA's research program in severe storms is headed by the National Severe Storms Laboratory.

Modeling is the basic tool and hope of current research.

There are two major approaches to the modeling of severe storms. The first utilizes parameters that are routinely forecast by the large-scale numerical models and that are statistically related to severe weather events. The second method is to construct dynamic prediction models of individual, small-scale weather disturbances.

A typical three-dimensional grid of a large-scale numerical model consists of a horizontal array of 50 x 50 and 10 vertical levels, for a total of 25,000 mesh points. Typically, six variables (temperature, humidity, pressure, and three components of velocity) are defined at each data point. Thus 150,000 elements of data represent the state of the atmosphere at a given moment.

The mesh size of the large-scale models cannot simply be reduced and applied to the small-scale phenomena. Not only do the observational and computer requirements increase rapidly as the mesh size is reduced; some of the important physical processes differ on the two scales.

The reason is that the traditional source of data for the operational, large-scale models has been the radiosonde, which provides accurate temperature, wind and moisture data at many levels in the atmosphere. The average horizontal spacing between radiosonde stations in the United States is about 400 km; as a result, important weather-producing systems with horizontal dimensions less than 400 km are either missed entirely or grossly misrepresented by the conventional network.

Reducing radiosonde spacing presents economic problems: the obvious remedy is satellite coverage.

Indeed, there is consensus in the research community that the comprehensive spatial coverage provided by satellite data will enhance model performance, if current research efforts can yield the required sensing accuracy.

OSTA's Severe Storm discipline Program provides research and technology support to responsible weather forecasting agencies, principally within NOAA.

Historically, OSTA technologies have aimed at: using spaceborne optical, IR, passive microwave sensors to observe meteorological phenomena and measure their key parameters; transmitting timely data to users, local and global; assimilating asynoptic data into existing and developmental numerical models to test measurement strategies and verify the contribution of satellite data. The data sets developed by OSTA scientists include cloud cover, temperature soundings, wind fields from cloud motions.

Current OSTA Program

OSTA's efforts comprising the severe storms discipline fall into six categories of R&D Activities.

SS 1 Severe Storm Indices

Remotely sensed data augmented by conventional meteorologic data are used to parameterize the precursor meteorologic conditions for storm development. Emphasis is on the determination of the necessary and/or sufficient conditions, in terms of wind, temperature and humidity fields required to initiate storm activity and upon verification of hypothesis of the mechanics of severe storm initiation.

Understanding of the necessary or sufficient meteorologic conditions for severe storm initiation; and of the associated mechanics of severe weather development is a must to improve short-range forecasts of severe meteorologic activity such as tornadoes, and excessive rates of precipitation, lightning and hail.

SS 2 Severe Storm Structure

Development of interactive interpretation techniques to augment conventional weather radar with satellite data: to assess cloud parameters and wind, moisture, and temperature fields associated with severe storm phenomena. The techniques will aid in statistical and physical examinations of the relationship of changes of severe storm's structure to its intensity and movement. Comparison of results with in-situ measurements will be used to verify and evaluate the techniques' utility.

Satellite data offers a valuable complement to conventional weather radar for defining and monitoring the changing kinematic structure of a severe storm.

SS 3 Storm-Environment Interaction

Use of satellite observations to investigate the Mesoscale coupling between internal and external severe storm environments, specifically; the physical processes of interchange of momentum, heat and moisture between the storm and the larger-scale environment and the role played by these processes in determining severe storm intensity, longevity and motion.

Description of the coupling processes between a storm and its surrounding environment is an essential step toward prediction of storm intensification, motion and dissipation.

SS 4 Integrated Severe Storm Modeling

Development of statistical and numerical models to improve forecast of severe storm activity utilizing the additional meteorological information provided by satellite data input. Storm simulations utilizing various models initialized with and without satellite data are used to evaluate the potential and limitations of satellite information. Developments emphasize the combination of satellite and conventional data for use in OSTA-developed and externally provided severe storm models.

SS 5 Severe Storms Detection & Intensity Measurement

Development of techniques for detecting severe storms and examining the energetics of storm activity. Particular emphasis is placed upon determining the optimal mix of satellite and radar data required for an operational storm monitoring system, and upon the determination of parameters which can be monitored remotely for the estimation of storm severity and location.

Enhancement of the capability to detect the onset and intensity of severe storms affords operational agencies inputs for more timely and improved severe weather warning/advisories.

SS 6 Crop Freeze Potential

Evaluation of transfer of satellite-based freeze forecasting techniques developed for use in Florida to mountainous U.S. areas. It is performed by relating the accuracy of forecast of surface temperature to characteristics of the terrain, to assess which topographic conditions are suitable for successful system performance.

The availability of a practical crop freeze forecast system can result in significant monetary savings to producers through reduced losses and reduction in unnecessary usage of crop heaters. The key step in implementing such a system is the identification of the conditions conducive to success.

Near Future OSTA Program

The program's philosophy is to emphasize the transfer of space-derived Severe Storms forecasting aids, and to assess the impact of space data on the performance of mesoscale models. The program is structured to foster understanding of the relationship between atmospheric state and flux and local severe storm observables. This includes case studies at storm-scale size, including microphysical and electrical observations, by means of high altitude aircraft overflights.

The key research elements of OSTA's near term Severe Storm program are:

- The value of Zero-G to provide an environment suitable to understand cloud formation and development through the use of the Atmospheric Cloud Physics Laboratory (ACPL) which will fly on the Shuttle/Spacelab will be addressed during ACPL flights 1, 2 and 3. These flights will occur during the period 1981-1983.

- Conduct of large scale experiments to demonstrate the utility of severe storms observing and forecasting techniques using remote sensing. This will be accomplished through a NASA Severe Storms Capability Demonstration in 1983.

- Definition of a severe storms observing system for a geosynchronous research satellite, to be accomplished through the assessment of measurement requirements and sensor capabilities during the period FY1980-83. System design should begin in FY83 with a system launch in FY86.

The key technology elements of OSTA's near term Severe Storm program are:

- Assessment of the value of VAS data to severe storms research and mesoscale meteorology, in a VAS Assessment Task.

Planning and software development for the VAS Assessment should begin in FY 1980 with case studies to be effective during FY 1981 concurrently with the VAS Demonstration.

- Development of satellite instrumentation to map the rate of lightning occurrence will be addressed to aid established users, such as power companies, airlines, telephone companies, and railroads, and for use as storm severity indicators to improve thunderstorm warnings. The design and development of the Lightning Mapper should begin in FY 1981 with the instrumentation launched on a geosynchronous spacecraft in the post 85 period.

- Development of an integrated, interactive, real-time, data collection, display and analysis system with comparative mapped displays of temperature, moisture, winds, lightning occurrence, clouds, radar reflectivity, etc., based upon observations and measurements from satellites, balloons, radar, and conventional sources. This system will then be linked to the NOAA PROFS (Prototype Regional Observing and Forecasting System).

Future OSTA Program

The identified long range goals of OSTA's Severe Storm program are:

- To conduct applied research on severe storm physics for use in the interpretation of remotely sensed data, for determination of antecedent conditions, heat budgets, thunderstorm top/intensity, downbursts associated with tornadoes, lightning occurrence and spectra, cloud microphysics, ionospheric waves associated with hail and tornado regions, tropical cyclone kinematics/energetics.

- To develop and demonstrate the merging of remotely sensed data with conventional meteorologic data, e.g. cloud height and rate of change from IR, flash flood indicators, thunderstorm cloud growth rate relationships, cloud type determination, rainfall rate estimation.

- To develop nowcasting models, tropical cyclone intensification models, tropical cyclone course change models, freeze line observations and freeze nowcasting techniques.

Figure 9.1 presents a graphic synopsis of OSTA's Severe Storms Program.

The first portion of the figure reflects the space missions, current and projected, whose data products support the Program. The subsequent portion and continuation sheets reflects the Program's endeavors for each identified R&D Activity.

Each element is referenced to its pertinent source documents; their titles are listed at the Figure's end.

9.2 Relationships between Data Services and the Severe Storms Discipline

Figure 9.2 summarizes the requirements for data products expressed by the users.

Users are interested in obtaining parameters. These are intermediate information products derived from sensor measurements, elaborated via the application of appropiate algorithms. For example, cloud height information derives from remotely sensed cloud-top radiance data elaborated in conjunction with cloud-top emissivity, cloud type, atmospheric absorption, sensor calibration data.

FIGURE 9.1

SEVERE STORM DISCIPLINE TIMELINE

OSTA MISSIONS

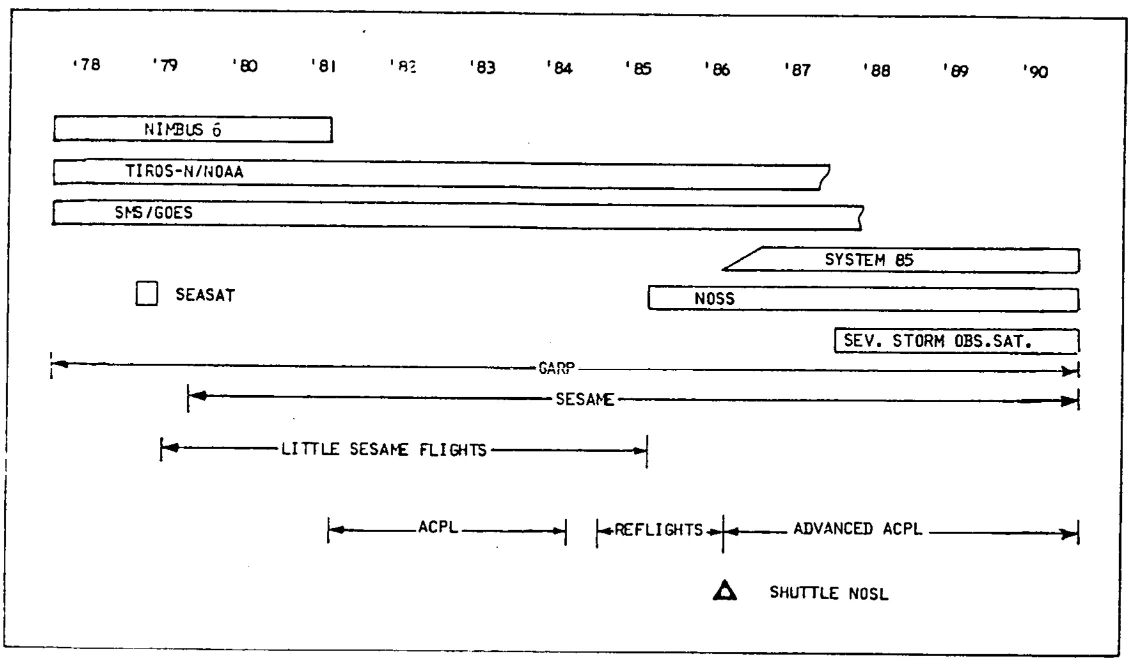


FIGURE 9.1

SEVERE STORM DISCIPLINE TIMELINE

R & D ACTIVITIES

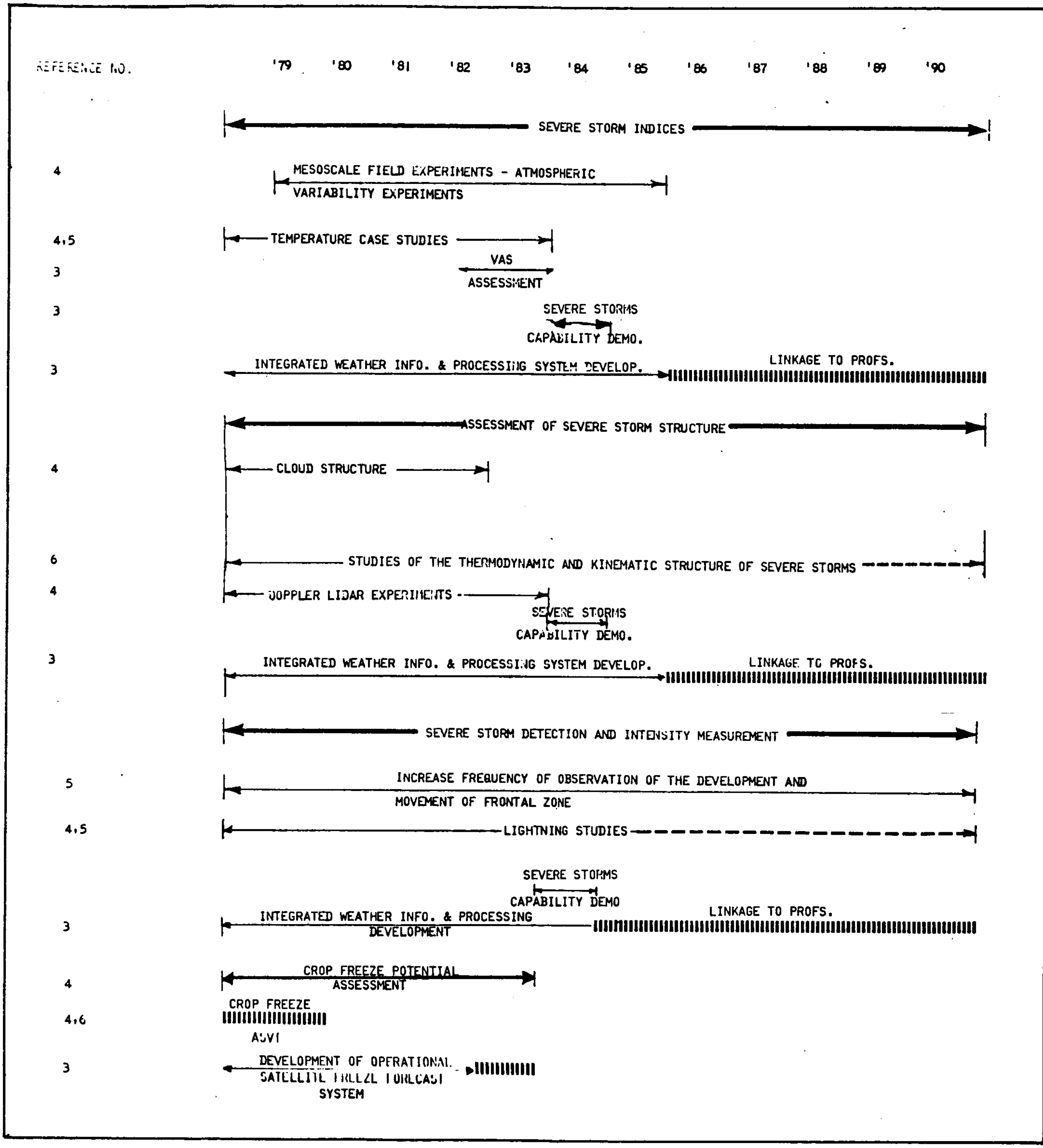
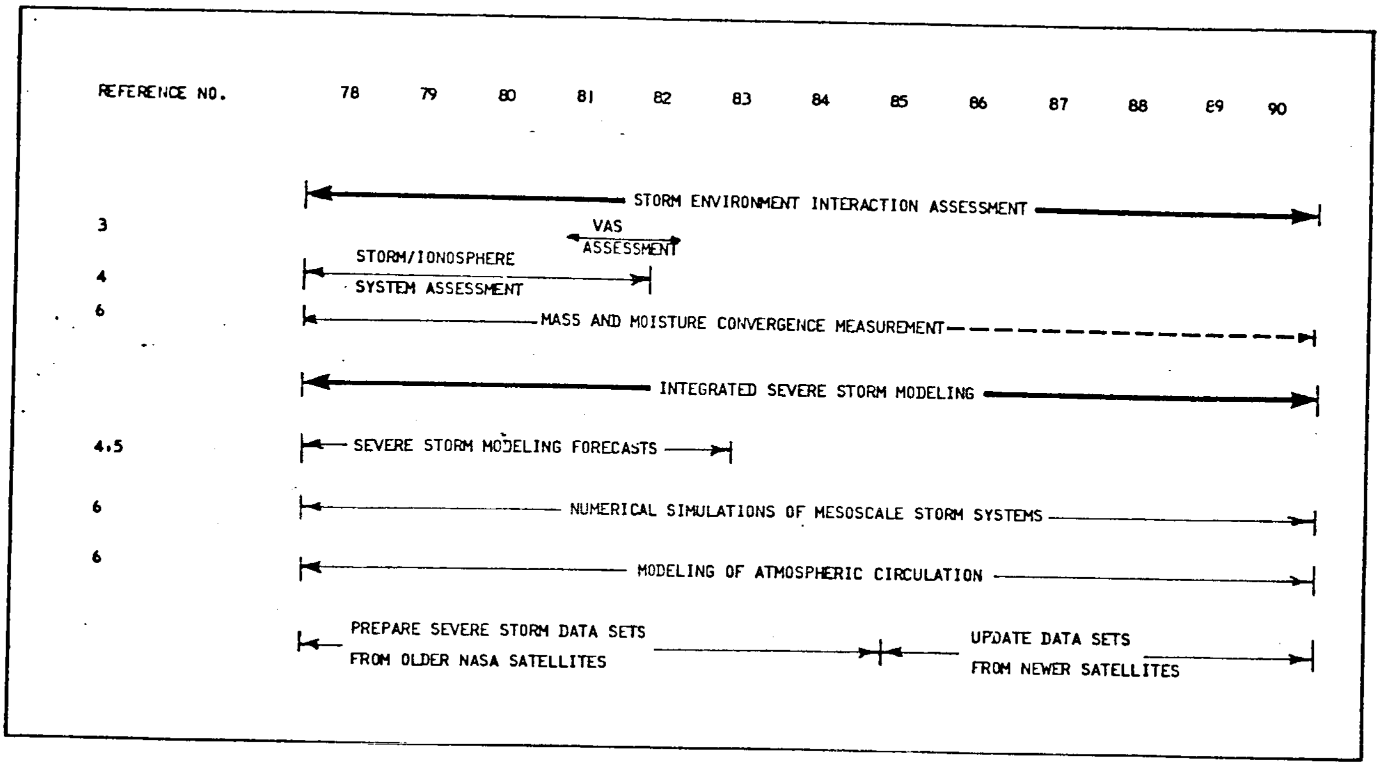


FIGURE 9.1

SEVERE STORM DISCIPLINE TIMELINE (CONT''D)

R & D ACTIVITIES



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4. NTOPS
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LEGEND

1 Flight Mission
2 Program Emphasis
3 R&D Activity
4 Continuous Activity
5 Technology Transfer (Pilot/Application Tests Etc.)
6 Short Term Event
7 Initial Operational Capability
8 All Investigation Classes

FIGURE 9.2

USER REQUIREMENTS FOR SPACE DATA PRODUCTS, SEVERE STORMS DISCIPLINE

	NOAA 2	NIMBUS 6			SEASAT	SMS GOES	TIROS N		GOES-D	SHUTTLE	NOSS		SYSTEM 85		STORMSAT	
PARAMETERS	VHRR	ESMR	SCAM	HIRS	SCAT	VISSR	TOVS (MSU)	AVHRR	VAS	NOSL	SCAT	LAMMR	VISSR-FOLLOW	AVHRR-FOLOW	ASSIR	MASR
VERTICAL WIND PROFILE					●	●			●		●	●	●		●	
VERTICAL WIND SHEAR						●			●				●		●	
CLOUD MOTION						●			●						●	
CLOUD TOP VERTICAL MOTION			●			●			●				●			
CLOUD COVER	●			●		●		●	●				●	●	●	
CLOUD HEIGHT				●		●			●				○		●	
CLOUD THICKNESS			●										●			
VERTICAL HUMIDITY PROFILE			●	●			●		●			●			●	●
PRECIPITABLE WATER PROFILE		●	●	●								●	●			●
PRECIPITATION RATES		●										○				●
LIGHTNING FLASH										●						
VERTICAL TEMP. PROFILE		●	●	●			●	●	●					○		●
CLOUD TOP TEMP.						●							○		●	
LAND SURFACE TEMP.		●	●	●		●		●				○		●		

DATA BANKS	VHRR	ESMR	SCAM	HIRS	SCAT	VISSR	TOVS (MSU)	AVHRR	VAS	NOSL	SCAT	LAMMR	VISSR-FOLLOW	AVHRR-FOLOW	ASSIR	MASR
NOAA/NESS	●					●	●	●	●				●	○	●	●
NCC/SDS	●					●	●	●	●				○	○		
NSSDC		●	●	●						●						
JPL/SEASAT CDHF					●											
NOSS/PPF											●	○				

PRODUCTS		VHRR	ESMR	SCAM	HIRS	SCAT	VISSR	TOVS (MSU)	AVHRR	VAS	NOSL	SCAT	LAMMR	VISSR-FOLLOW	AVHRR-FOLOW	ASSIR	MASR	PRODUCT TOTALS
1980	TAPES/YR.	393	90	108	90	160	3158	72	-	-	-	-	-	-	-	-	-	4071
	IMAGES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OTHER/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	- -
	G BITS/YR.	14	3	4	3	6	111	3	-	-	-	-	-	-	-	-	-	142
1985	TAPES/YR.	-	-	-	-	-	2231	238	31	2195	20	238	144	178	32	-	-	5307
	IMAGES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OTHER/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	G BITS/YR.	-	-	-	-	-	78	8	1	77	0.7	8	5	6	1	-	-	186
1990	TAPES/YR.	-	-	-	-	-	-	-	-	-	-	58	144	446	238	2293	3007	6186
	IMAGES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OTHER/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	G BITS/YR.	-	-	-	-	-	-	-	-	-	-	2	5	16	8	80	105	216

NASA users in the Severe Storms Discipline are in the process of developing such algorithms. For this purpose, they wish to receive raw space data, augmented by the auxiliary data summarized in Table 9.1.

The volume of required space data shows a moderate increase through the 1980-1990 decade, from approximately 140 to 220 Gigabits/year. The volume required of auxiliary data, from Table 9.1, is approximately one third that of the space data.

From Figure 9.1, OSTA's program is devoted to research efforts through approximately 1984. Table 9.2 shows that the corresponding acceptable time lapse of data delivery is of order four weeks.

Figure 9.1 shows for the post-1984 time frame a somewhat rapid transition from R&D to technology transfer activities. These latter could acquire two forms: 1) algorithms and models developed by NASA researchers are tested by other federal agencies upon their facilities, in this case NOAA's or 2) they are tested on NASA facilities with participation from sister agency personnel.

The first form of transfer does not impact ADS because by current definition, ADS is intended to service NASA researchers only. In the second event, the timeliness requirements for data transfer would be "real time." Specifically for Severe Storms, it is important to distinguish between the direct transfer of space data from satellite to users, and the transfer to users of previously archived data. Only the latter is within the purview of ADS as currently defined. Thus the meaning of "real time", Table 9.2 signifies a time lapse commensurate with the need to call from archives data related to the satellite's primary real-time function.

TABLE 9.1

USER REQUIREMENTS FOR AUXILIARY DATA PRODUCTS, SEVERE STORMS DISCIPLINE

TYPE OF DATA	DATA PRODUCT FORMAT	SOURCE	ESTIMATED YEARLY PRODUCT VOLUME* SS 1	SS 2	SS 3	SS 4	SS 5	SS 6	TOTAL	USE OF DATA PRODUCT
Surface Observations From NWS Data Stations	Digital (800 BPI) tape of Wind, Temperature, Humidity, Pressure and precipitation rate, cloud cover and cloud base height	EDIS (NCC, NMC	36	-	15	44	68	-	163	Calibration and Verification of satellite data
Rawinsonde Observations	Digital (800 BPI) tape of Wind, Air Temperature and Humidity at 33, 50 mb pressure levels.	EDIS (NCC)	36	-	15	44	68	-	163	Vertical correction of satellite derived wind, temperature and moisture fields for input to multi-level high resolution regional meteorologic models.
Conventional Weather Radar	Digital, high density (1600 BPI) calibrated radar intensity tape	EDIS (NSSFC, NSSL) USCG	135	35	-	58	380	-	608	Used to map cloud characteristics and regions and rates of precipitation for correlation with satellite data (VISSR, SMMR...)
Doppler Radar	Digital high density (1600 BPI) dual doppler radar tape	EDIS (NSSL)	45	-	15	20	100	-	180	3-dimensional mapping of velocity and precipitation fields for correlation with visible IR and microwave satellite imagery
Multisource Meteorologic Analysis Data	Digital (800 BPI) tape of limited area fine mesh analysis wind, temperature, and moisture data	EDIS (NMC, NSSFC, NHC) FNWC AFGWC	36	-	15	44	68	-	163	Supplementation of satellite derived wind, temperature and moisture fields for input to high resolution regional meteorologic models and verification of analysis results.

*Volume specified in number of indivdual products (Tapes, maps, reports....)

TABLE 9.2

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: SEVERE STORMS

(OBSERVATIONS)

	R & D ACTIVITY					
	SEVERE STORM INDICIES	ASSESSMENT OF SEVERE STORM STRUCTURE	STORM ENVIRONMENT INTERACTION ASSESSMENT	INTEGRATED SEVERE STORM MODELING	SEVERE STORM DETECTION AND INTENSITY MEASUREMENT	CROP FREEZE POTENTIAL
REQUIREMENTS	SS1	SS2	SS3	SS4	SS5	SS6
Horizontal Resolution (KM)						
Minimum	3	1	5	1	5	5
Maximum	150	150	150	100	.0	100
Modal	5-150	1-20	5-100	5-100	5-50	5-100
Vertical Resolution (KM)						
Minimum	.5	.5	0.5	0.5	0.5	N.A.
Maximum	100	30	5	30	10	N.A.
Modal	2-5	0.5-30	2-5	2-5	0.5-20	N.A.
Frequency						
Minimum	1 min.	1 min.	1 min.	1 min.	1 min.	1 min.
Maximum	30 min.	1 min.	3 hrs.	1 min.	1 min.	1 hr.
Modal	1-30 min.	1 min.	1 min.-3 hrs.	1 min.	1 min.	1 hr.
Data Delivery						
Research Investigations	4 Weeks	4 Weeks	4 Weeks	4 Weeks	4 Weeks	4 Weeks
Technology Transfer	Realtime	Realtime	Realtime	Realtime	Realtime	Realtime

TABLE 9.2 (cont'd)

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: SEVERE STORMS (SPECIAL SERVICES)

	R & D ACTIVITY					
REQUIREMENTS	SS 1	SS 2	SS 3	SS 4	SS 5	SS 6
Reformat Satellite & Radar Data for Use on AOIPS	X	X		X	X	
Reformat Conventional Surface Upper Air Data Into a Computer Compatible Form	X		X			
Continue/Expand GSFC Multi-source Data Support Services	X	X	X	X	X	X
Maintain An Archive of Raw VISSR Data	X	X	X	X	X	X
Collect & Maintain Multi-source Meteorologic Data Sets Relevant to Severe Storm Activity	X	X	X	X	X	X
Digitize and Format Radar Data to Correspond to Satellite Coordinates			X		X	
Format Satellite Data Into A Computer Compatible Form			X			X
Format Radar Data Into A Computer Compatible Form			X			X
Format Rawinsonde Data Into A Computer Compatible Form			X			
Reformat Fine Mesh Data Into A Computer Compatible Form				X		
Provide All Auxiliary In A Computer Compatible Form					X	

TABLE 9.2 (Cont'd)

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: SEVERE STORMS

(STANDARD ALGORITHMS)

	R & D ACTIVITY					
REQUIREMENTS	SS 1	SS 2	SS 3	SS 4	SS 5	SS 6
Precursor Storm Indicies	X					
Improved Storm Forecast Models	X			X		
Temperature Field Estimates		X				
Moisture Field Estimates		X				
Wind Field Estimates		X				
Atmospheric Kinetic Energy Budget Model			X			
Improved Severe Storm Locator Storm Intensity Estimator					X	
Land Surface Temperature Mapping						X

During the time frame in which the research mode predominates, approximately through 1984, ADS data transfer requirements can be satisfied by a service of data rate comparable to that of the U.S. mail.

In the second portion of the 1980-1990 decade, technology transfer activities will commence. These will be embodied into the initial test of NOAA's Prototype Regional Observing and Forecasting System (PROFS). The plan calls for a linkage to PROFS. NASA researchers will require accelerated retrieval from archives of data related to severe storms, for the purpose of assisting NOAA in performing their appointed functions. The estimated delivery times are of order of days.

The slow data delivery requirements of the early time frame do not necessarily connote that electronic linkages are not desirable. They simply indicate that the choice of the link is driven by economic cost-effectiveness rather than by technical urgency. For example, a plausible ADS scenario may well incorporate a centralized accounting, scheduling and data traffic monitoring facility; which maintains track of expenditures on the part of the users, supplies them budgetary estimates, advises them of impending depletion of project funds. Further analysis might reveal that such centralized management function can be performed more cost-effectively through use of electronic data links than through other conventional alternatives; quite apart from considerations of speed.

As a gross sizing of the "electronic link" alternative during the "slow" R&D time frame, the corresponding transfer requirements are such as to engage the equivalent of approximately 20 data links of 1,200 bps capacity each, operating on a one shift, normal work week basis.

Because the driver is economics, not technology, system tradeoffs can exploit to the fullest special tariff structures and price breaks: e.g. discounts for off-time operation, quantity savings from use of bulk bandwidths, use of satellite links whenever transfer distance exceeds the cost breakpoint (currently of order 900 kilometers).

Analysis of Tables 9.2 and 9.3 permits the inference that user services related to imagery manipulation---e.g. geocoding, superposition of formats, gridding---will impose moderately significant technological requirements upon ADS. This is because relatively modest spatial resolutions are adequate to satisfy the users.

Users need to have available approximately 8 significant types of algorithms, Table 9.2. A potential evolutionary trend in the latter part of the 1980-1990 decade is the transition from user-peculiar development of these algorithms to their routine use---after the necessary confidence resulting from high "batting averages" will have been achieved.

Such an evolutionary development would open the ADS to the opportunity of providing a centralized algorithm processing function. Algorithms which reach fruition would be transferred to this function for conventional processing: the researcher would retain the function of developing the newer generations of algorithms.

TABLE 9.3

DATA SERVICE REQUIREMENTS FOR THE SEVERE STORMS DISCIPLINE

		SEVERE STORM INDICES	ASSESSMENT OF SEVERE STORM STRUCTURE	STORM ENVIRONMENT INTERACTION	INTEGRATED SEVERE STORM MODELING	SEVERE STORM DETECTION & INTENSITY MEASUREMENT	CROP FREEZE POTENTIAL
DATA LOCATION	Data Catalog						■
	Data Dictionary	■	■	■	■	■	■
	Computer Search						
DATA EDITING	Quality Control						
	Data Sorting	●	●	●	●	●	
REFORMATTING	Form Conversion	■	■		■	■	
	Code Conversion						
	Coordinate Conversion	■	■		■	■	
	Scale Conversion						
ASSEMBLY	Data Segment Preparation	■	■	■	■	■	■
	Data Set Preparation	■	■	■	■	■	
DATA INTEGRATION	Single-Source Multi-temporal Data Registration	●	●		●	●	
	Single-Source Multi-temporal Data Merging						
	Multi-Source Uni-temporal Data Registration	●	●	●	●	●	●
	Multi-Source Uni temporal Data Merging						
	Data Gridding	●	●	●	●	●	
	Data Overlay						
	Image Mosaicing						
SPECIAL PROCESSING	Radiometric Correction						●
	Geometric Correction						
	Other						
DATA MGM'T	Data Archiving	■	■	■	■	■	
	Data Delivery	1 ■	1 ■	1 ■	1 ■	1 ■	1 ■
OTHER		2	2	2	2	2	2

■ High Value Data Service ● Desirable Data Service

Note 1: Real Time for Tech. Transfer
2: Interactive Data System

9.3 Implications of ADS in the Severe Storms Discipline

The consensus of the users in the Severe Storms Discipline focuses upon the following key data-related points:

- Users obtain most of their space data through the Severe Storms data support activities available at the GSFC GLAS Facility. GLAS provides data linkage with NOAA/NESS and archiving of the highly perishable high resolution VISSR data. Upon user request this data is reformatted on AOIPS and delivered to the user within 1-2 months.

- Most auxiliary data is obtained through EDIS: deliveries of order 2-3 months are common.

- Most current users engage in research efforts: they are, in theory, not affected by data delivery times. In practice, the long wait slows down the pace of their efforts, thus the *efficienty of the R&D effort.*

  The timing with which the users feel "comfortable" is 30 days.

- The upcoming Severe Storms technology demonstration will serve to demonstrate the utilization of OSTA-developed storm forecast and monitoring capabilities. Users involved in this demonstration will require data delivery on a real time basis.

- The majority of researchers indicate that even though the cost of individual data products is nominal, the deficiences in the current data delivery system seriously impact their budgets. Their choices lie between ordering an excess of data products from which to glean the good samples, or devote excessive time to preselection of the products to be ordered so as to minimize the probability of receiving flawed data. Their primary mode of operation is the latter; in either event, current modes of data delivery seriously impact their budgets.

To remedy this problem, *maintenance of a comprehensive, continually updated catalog is required. This catalog should identify location and general content of the data, but additionally provide indications as to the quality of each datum.*

In other words, the users want a data directory augmented by a running, rapidly available log of the pertinence and quality characteristics of *individual data.*

- The users cannot exploit all the pertinent sources of auxiliary data of which they have knowledge, due to two principal reasons: the financial constraints aforesaid; and the time required to reformat the auxiliary data to match the format of the space-derived data.

  An example offered by users relates to ground radar data, used to complement satellite storm observations. A limited amount of radar data is currently available in digital format; virtually all must be subjected to appropriate geocoding transformations against satellite data. Thus, most of the available analog radar data is not currently being used.

- *The provision of low-cost geocoding and reformatting services -- whether centralized or individual -- would be highly desirable, provided that their quality and reliability match that of currently employed non-automatic methods.*

In summary, the principal impact of an ADS upon the users of the Severe Storms Discipline would be reduction of time and expense required to acquire data in readily usable formats. In addition, ADS would tend to enhance user awareness of available data and utilization of data not currently employed because of deficiencies in data formats.

Five key ADS functions which would promote increased efficiency are:

- Provision of a data directory and concurrent running data log

- Provision of efficient methods of combining data

- Cost effective geocoding and reformatting services

- Acceleration of data delivery times for researchers by a factor of two to four. Note, however, that most of the delay currently experienced is caused by the internal reaction time of the data bases and of the data reformatting facility (AOIPS); thus, the simple provision of faster data transfer links would in this case not suffice. More sophisticated strategies would need to be employed.

- Provision of quasi real time capability for users involved in technology demonstration.

10.1 Description of Objectives and Content

The Environmental Protection Agency (EPA) is the Federal agency responsible for administering the "Federal Water Pollution Control Act." The EPA has quality monitoring and assessment responsibility for all national lakes, streams and waterways.

The monitoring and assessment mission of the EPA is directed toward a wide spectrum of objectives related to chemical and biologic water parameters.

Remote sensing is seen as a cost effective means of augmenting the water quality and monitoring mission of the EPA. To this end, OSTA's Water Quality Discipline Program supports EPA activities.

OSTA's Water Quality program focuses on laboratory and aircraft investigations to understand the physics of remote sensing of waterborne pollutants and in the development and application of remote sensing techniques. Developed techniques are transferred to EPA.

The history of the OSTA Water Quality Discipline Program contains a number of projects in which remote sensing technology has been applied in a limited way to specific environmental problems (i.e., ocean dumps, red tide, etc.) or to regional issues (i.e., Great Lakes, Chesapeake Bay, etc.).

Several joint NASA/user regional programs, well along in the planning and demonstration phases, should continue to provide greater credibility for interagency application of remote sensing. These programs include the

Great Lakes Experiments, the Landsat Lake Classification Evaluation, and the Ocean Dumping Program. They have already established a committed user involvement.

The first space-acquired, regional water quality data is available from the Coastal Zone Color Scanner (CZCS) on Nimbus 7, whose aim is to measure chlorophyll concentration, sediment distribution, gelbstoff (yellow substance) concentration as a salinity indicator, and the surface temperature of coastal waters and the open ocean.

Current OSTA Program

Current OSTA efforts within the Water Quality Discipline Program fall into two categories:

WQ 1 Pollutant Transport/Dispersal

Satellite remote sensing will be used in efforts to initialize and validate models for assessing coastal and inland water transport processes.

Pollutant transport and dispersal is important to point source, land runoff and other pollutant monitoring and enforcement; for thermal plume assessments from power plants or other hot water emitters and for assessing the impact of various control policies and water quality standards.

WQ 2 Pollutant Effects on Bioprocesses

Remote measurement of chlorophyll-A will be used as indicators of pollutant impact and a guide to understanding the resultant dynamics of biological productivity. Multispectral classification techniques for assessing eutrophic conditions, developed for lakes and estuaries, will continue to be improved and applied.

Over the past decades, pollutants have threatened or destroyed marine and fresh water fisheries, and seriously affected local recreation potentials. Excessive nutrients, e.g. phosphates and nitrates, lead to eutrophication, e.g. nuisance algal growth, excessive attached and surface plant growth, reduction in dissolved oxygen. Better understanding of waterborne biological growth and chemical reactions can aid pollution control and restore endangered water resources.

Near Future OSTA Program

The Water Quality Discipline Program may be subject to revision in the near future. As currently proposed, its emphasis is on understanding the interactions between pollutant transport and dispersion on coastal, ocean, lake and reservoir bioprocesses. It envisions university contributions, aimed at developing operational pollution monitoring and control requirements.

The program's currently proposed philosophy is to:

- Support the NASA/EPA hazardous substance program
- Develop sensors and techniques to measure quality of, and pollutant impact on water.

The program's research elements are:

- Data analysis of field measurements monitoring oil spill and ocean wastes
- Implementation of a joint NASA/EPA hazardous substance program.

An important technological emphasis is the support of the definition of a satellite-assisted nationwide water quality monitoring program for the late 1980's, integrating the common elements of diverse regional water quality needs.

Principal related technology developments are:

- The application of laser techniques to measure water content, with emphasis on chlorophyll and/or temperature
- Laboratory and field research to relate remote sensing to the determination of chlorophyll-A for coastal zone monitoring (field studies in North Atlantic with NOAA/NMFS).

Future Program

OSTA's Water Quality Discipline Program is a continuing and evolving effort with the objective of supporting user agencies in assimilating space technology into their operational functions. Thus far, results show that the synoptic view provided by remote sensors from spacecraft and aircraft should permit expanding the heretofore limited surface sampling efforts to larger areas for which monitoring and modeling are required, e.g. the coastal zone and oceanic regions.

The types of research activities by federal participants in the water pollution program supported by OSTA should continue throughout the decade.

Figure 10.1 presents a graphic synopsis of OSTA's Water Quality Program as currently envisioned. As already mentioned, this program is subject to modification in the near future.

FIGURE 10.1

WATER QUALITY DISCIPLINE TIMELINE

OSTA MISSIONS

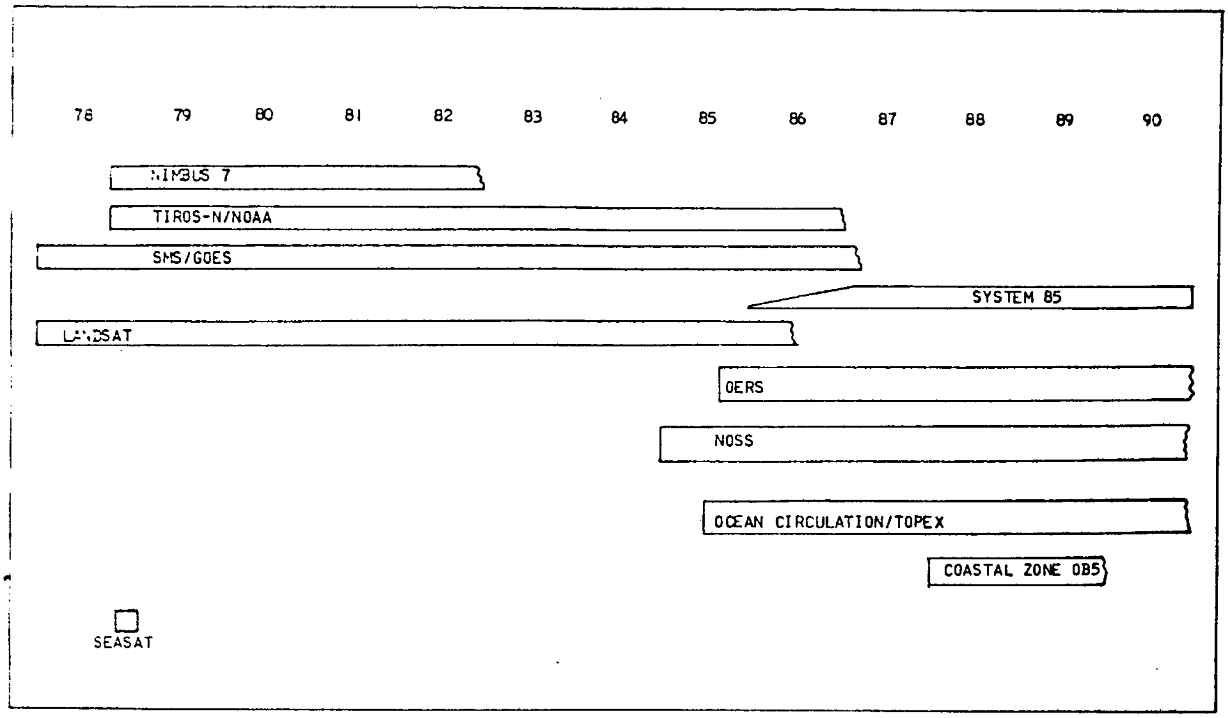
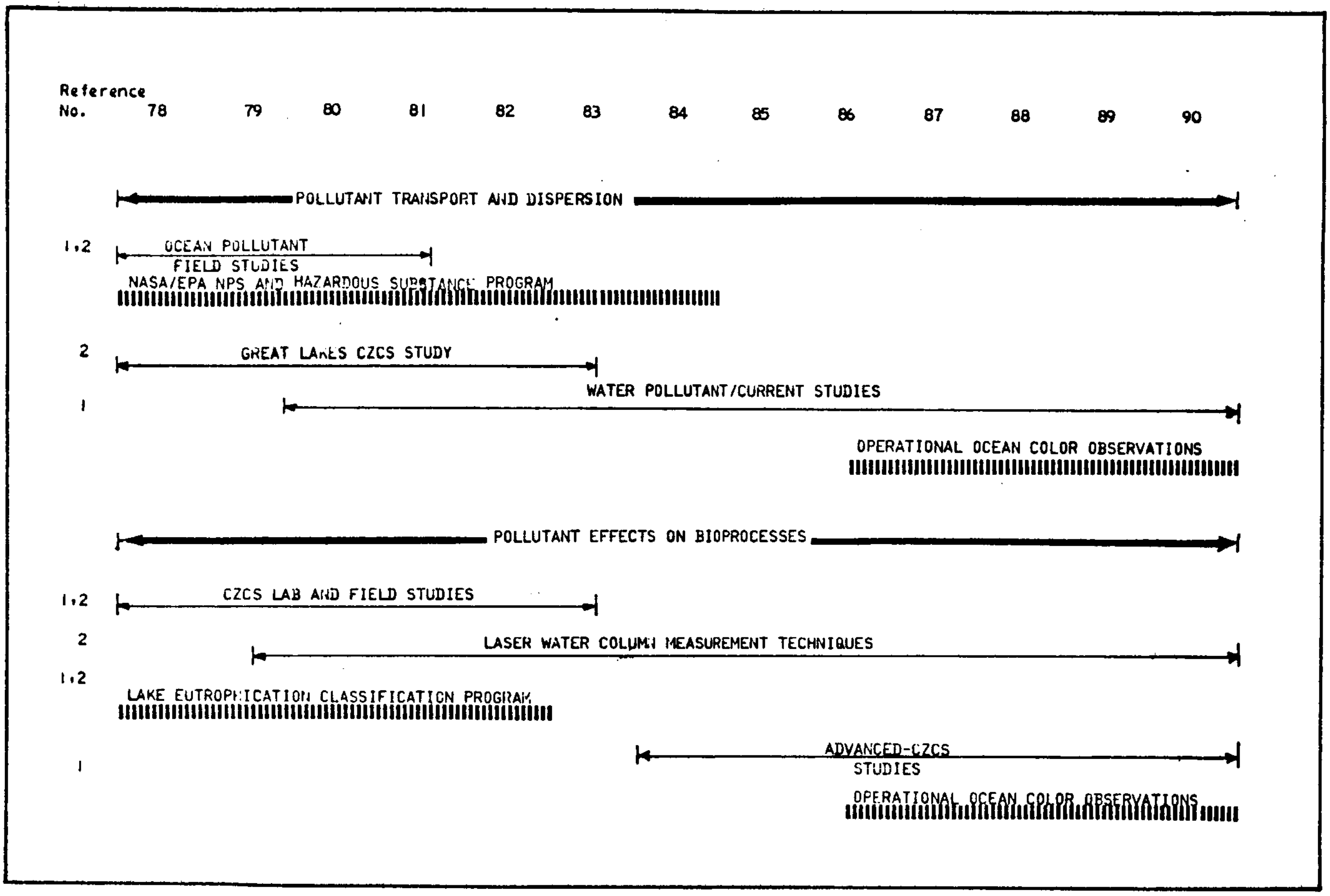


FIGURE 10.1

WATER QUALITY DISCIPLINE TIMELINE

R & D ACTIVITIES



REFERENCES:
1) DATA PROVIDED BY DISCIPLINE SCIENTIST

2) ENVIRONMENTAL OBSERVATION DIVISION 5-YEAR PLAN FY =81-85 TO NASA PLANNING COUNCIL, 1979

LEGEND

1 Flight Mission
2 Program Emphasis
3 R&D Activity
4 Continuing Activity
5 Technology Transfer (Pilot/Application Tests Etc.)
6 Short Term Event
7 Initial Operational Capability
8 All Investigation Classes

The first portion of the Figure reflects the space missions, current and projected, whose data products support the Program. The subsequent portion and continuation sheet reflects the Program's endeavors for each identified R&D Activity.

Each element is referenced to its pertinent source documents; their titles are listed at the Figure's end.

10.2 Relationships between Data Services and the Water Quality Discipline

Figure 10.2 summarizes the requirements for data products expressed by the users.

Users are interested in obtaining parameters. These are immediate information products derived from sensor measurements, elaborated via the application of appropriate algorithms. For example, surface temperature information derives from remotely sensed radiance data elaborated in conjunction with surface emissivity, atmospheric absorption, sensor calibration data.

At this time, NASA users in the Water Quality Discipline are in the process of developing such algorithms. For this purpose, they wish to receive raw space data, augmented by the auxiliary data summarized in Table 10.1.

The volume of required space data shows a moderate increase through the 1980-1990 decade, from approximately 5 to 13 Gigabits/year. The volume required of auxiliary data, from Table 10.1, is approximately three-fifths that of the space data.

FIGURE 10.2

USER REQUIREMENTS FOR SPACE DATA PRODUCTS, WATER QUALITY DISCIPLINE

		SEASAT A		NIMBUS 7	LANDSAT C	GOES	TIROS N	LANDSAT D	NOSS				TOPEX	COASTSAT	
PARAMETERS		ALT	SASS	CZCS	MSS	VISSR	AVHRR	TM	ALT	CZCS II	SCAT	AVHRR	ALT	COLORI-METER	
WATER SURFACE HEIGHT		●							●				●		
MULTISPECTRAL WATER REFLECTANCE				●	●			●		●				●	
SURFACE WATER TEMPERATURE						●	●					●			
SURFACE WIND SPEEDS			●								●				
DATA BANKS															
CSFC/IPD				●											
NOAA/NESS		●	●			●	●								
EROS					●			●							
NOSS/PPF									●	●	●	●			
NSSDC														●	
PRODUCTS															**PRODUCT TOTALS**
1980	TAPES/YR.	20	20	-	-	50	40	-	-	-	-	-	-	-	130
	IMAGES/YR.	-	-	120	120	-	-	-	-	-	-	-	-	-	240
	OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	G BITS/YR.	1	1	-	-	2	1	-	-	-	-	-	-	-	5
1985	TAPES/YR.	-	-	-	-	90	90	100	20	-	40	25	20	-	385
	IMAGES/YR.	-	-	-	-	-	-	50	-	250	-	-	-	-	300
	OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	G BITS/YR.	-	-	-	-	3	3	4	1	-	1	1	1	-	13
1990	TAPES/YR.	-	-	-	-	-	-	-	50	-	100	175	50	-	375
	IMAGES/YR.	-	-	-	-	-	-	-	-	225	-	-	-	225	450
	OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	G BITS/YR.	-	-	-	-	-	-	-	2	-	4	6	2	-	13

TABLE 10.1

USER REQUIREMENTS FOR AUXILIARY DATA PRODUCTS, WATER QUALITY DISCIPLINE

TYPE OF DATA	DATA PRODUCT FORMAT	SOURCE	ESTIMATED YEARLY PRODUCT VOLUME*			USE OF DATA PRODUCT
			WQ 1	WQ 1	TOTAL	
Sea Surface Meteorologic and Oceangraphic Data (Date Bouy Data)	Monthly digital (800 BPI) Data Bouy Summary Tape of sea surface wind and surface water temperature and surface currents	EDIS (NODC)	8	10	18	Correction and verification of satellite derived oceanographic data
Chlorophyll Concentration Data	Digital (800 BPI) tape of averaged yearly cholorphyll concentration measured at USGS National Stream Quality accounting Network stations	EDIS (NODC) WATSTORE	8 3	10 2	18 5	Calibration of satellite observations of water color to infer chlorophyll concentrations
	Hardcopy summary of chloro-phyll concentration at selected collection points (Data available for ≈ 200,000 collection points covering US lakes, streams and other waterways	STORET	4	3	7	
PhytoplanktonConcentration Data	Microfilmed cruise record of phytoplankton concentration data (available cruise and area sort)	EDIS (NODC)	8	10	18	Calibration of satellite observation of water color to estimate phytoplankton concentration
	Digital (800 BPI) tape of averaged yearly phytoplantor concentrations measured at USGS National Stream quality accounting Network Stations	WATSTORE	3	2	5	

*Volume specified in number of individual products (Tapes, maps, reports....)

TABLE 10.1

USER REQUIREMENTS FOR AUXILIARY DATA PRODUCTS, WATER QUALITY DISCIPLINE (CONT.)

TYPE OF DATA	DATA PRODUCT FORMAT	SOURCE	ESTIMATED YEARLY PRODUCT VOLUME*			USE OF DATA PRODUCT
			WQ 1	WQ 2	TOTAL	
Photoplankton Concentration Data	Hardcopy summary of phytoplankton concentration (cells/ml) at selected collection points	STORET	4	3	7	Calibration of satellite observation of water color to estimate phytoplankton concentrations
Zooplankton Concentration Data	Microfilmed cruise record of zooplankton concentration	EDIS (NODC)	8	10	18	Calibration of satellite derived observation water color to infer zooplankton concentration
	Digital (800 BPI) tape of averaged yearly zooplankton concentrations measured at U.S.G.S. National Stream Quality accounting Network Stations	WATSTORE	3	2	5	
	Hard copy summary of zooplankton concentration (cells/ml) at selected water quality data collection points	STORET	4	3	7	
Pesticides concentration Data	Digital (800 BPI) tape of averaged monthly pesticide, concentration measured at U.S.G.S. Pesticide program stations	WATSTORE	3	2	5	Pesticide concentrations are correlated with remotely sensed observations of land use to infer land use/pollutant loading factors
	Hard copy summary of averaged selected pesticide concentrations at water quality data collection paints within selected agricultural areas	STORET	4	3	7	

*Volume specified in number of individual products (Tapes, maps, reports....)

TABLE 10.1

USER REQUIREMENTS FOR AUXILIARY DATA PRODUCTS, WATER QUALITY DISCIPLINE (CONT.)

TYPE OF DATA	DATA PRODUCT FORMAT	SOURCE	ESTIMATED YEARLY PRODUCT VOLUME* WQ 1	WQ 2	TOTAL	USE OF DATA PRODUCT
Nitrates Concentration Data	Digital (800 BPI) tape of averaged yearly concentration of nitrates measured at USGS National Stream Quality accounting Network Stations	WATSTORE	3	2	5	Nitrate concentrations are correlated with remotely sensed values of land use to infor NFS pollutent loading factors
	Hard copy summary of Nitrogen Concentration at selected water quality data collection points	STORET	4	3	7	
	Microfilmed cruise tape of water chemistry samples	EDIS (NODR)	8	10	18	
Phosphorous Concentrated Data	Digital (800 BPI) tapes of averaged yearly phosphorous concentration measured at USGS National Stream Quality accounting Network Stations	WATSTORE	3	2	5	Phosphorous concentrations are correlated with remotely sensed values of land use to infer NPS pollutant loading factors
	Hard copy summary of phorous concentrations at locations selected from ~200,000 collection points	STORET	4	3	7	
	Microfilmed cruise record of ocean phosphorous concentrations	EDIS (NODC)	8	10	18	
Coliform Concentration Data	Digital (800 BPI) tape of averaged yearly coloform concentration and distribution measured at USGS National Stream Quality accounting Network Stations	WATSTORE	3	5	7	Coliform concentrations are correlated with remotely sensed observations of land use for estima tion of land use/pollutant loading factors and with water color observations for calibrating

*Volume specified in number of individual products (Tapes, maps, reports....)

TABLE 10.1

USER REQUIREMENTS FOR AUXILIARY DATA PRODUCTS, WATER QUALITY DISCIPLINE (CONT.)

TYPE OF DATA	DATA PRODUCT FORMAT	SOURCE	ESTIMATED YEARLY PRODUCT VOLUME*			USE OF DATA PRODUCT
			WQ 1	WQ 2	TOTAL	
Coliform Concentration Data	Hard copy summary of coloform counts at selected water quality data collection stations	STORET	4	10	14	Remote observations of water treatment plant effluent transport and dispersal
Suspended- Sediment Data	Digital (800 BPI) tape of averaged yearly suspended sediment concentration and distribution measured at USGS National Stream Quality accounting Network Station	WATSTORE	4	--	4	Calibration of satellite water color observations to infer sediment transport and distribution
Surface Meterologic Data (NWS Synoptic Data Station Observations)	Observations of surface winds, air temperature and precipitation available on digital (800 BPI) tape	EDIS (NCC, NMC)	7	5	12	Input to NPS Pollution Modeling
Fish Statistics	Yearly hard copy publication of Commercial Fishery yield for U.S. waters	NMFS	--	15	15	Fish statistics are correlated with pollutant concentrations to related the effects of pollutants on Bioprocesses

*Volume specified in number of individual products (Tapes, maps, reports....)

From Figure 10.1, OSTA's program is devoted to both research and technology transfer efforts throughout the 1980-1990 decade. Table 10.2 shows that the corresponding acceptable time lapse of data delivery is of order four weeks for research efforts, one week for technology transfer endeavors.

Thus, during the 1980-1990 decade, ADS data transfer requirements can be satisfied by a service of data rate comparable to that of the U.S. mail.

Commencing approximately 1986, portions of the program are expected to transition to operations. Since operational activities will most likely be performed by EPA or NOAA, employing EPA's or NOAA's facilities, they will probably not impact ADS: because, by current definition, ADS is intended to service NASA researchers only.

The slow data delivery requirements of the Water Quality discipline do not necessarily connote that electronic linkages are not desirable. They simply indicate that the choice of the link is driven by economic cost-effectiveness rather than by technical urgency. For example, a plausible ADS scenario may well incorporate a centralized accounting, scheduling and data traffic monitoring facility; which maintains track of expenditures on the part of the users, supplies them budgetary estimates, advises them of impending depletion of project funds. Further analysis might reveal that such centralized management function can be performed more cost-effectively through use of electronic data links than through other conventional alternatives; quite apart from considerations of speed.

TABLE 10.2

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: WATER QUALITY

(OBSERVATIONS)

	R & D ACTIVITY	
	POLLUTANT TRANSPORT AND DISPERSION	POLLUTANT EFFECTS ON BIOPROCESSES
REQUIREMENTS	WQ1	WQ2
Horizontal Resolution (KM)		
Minimum	0.1	0.1
Maximum	10	1.0
Modal	0.1	0.1-1.0
Vertical Resolution (KM)		
Minimum	N.A.	N.A.
Maximum	N.A.	N.A.
Modal	N.A.	N.A.
Frequency		
Minimum	1 Day	1 Day
Maximum	2.4 Hrs.	1 Day
Modal	1 Day	1 Day
Data Delivery		
Research Investigations	4 Weeks	4 Weeks
Technology Transfer	1 Week	1 Week

TABLE 10.2 (Cont'd)

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: WATER QUALITY

(SPECIAL SERVICES)

REQUIREMENTS	R & D ACTIVITY WQ1	R & D ACTIVITY WQ2
Reformat All Data to Conform to a Standard Georeferenced Grid	X	X
Compile Multisource Data Sets	X	X
Maintain A Catalog of Pertinent Satellite & Auxiliary Data	X	X

(STANDARD ALGORITHMS)

REQUIREMENTS	R & D ACTIVITY WQ1	R & D ACTIVITY WQ2
Pollutant Concentration Estimators	X	X
Water Current Estimators	X	
Temperature and Salinity Profiles		X
Chlorophyll and Plankton Estimators		X
Nutrient Concentration Estimators		X

As a gross sizing of the "electronic link" alternative, the corresponding transfer requirements are such as to engage the equivalent of approximately 1 to 2 data links of 1,200 bps capacity each, operating on a one shift, normal work week basis.

Because the driver is economics, not technology, system tradeoffs can exploit to the fullest special tariff structures and price breaks: e.g. discounts for off-time operation, quantity savings from use of bulk bandwidths, use of satellite links whenever transfer distance exceeds the cost breakpoint (currently of order 900 kilometers).

Analysis of Table 10.2 and 10.3 permits the further inference that user services related to imagery manipulation---e.g. geocoding, superposition of formats, gridding---will impose fairly significant technological requirements upon ADS. This is because relatively high spatial resolutions are required to satisfy the users.

Users need to have available approximately 5 significant types of algorithms, Table 10.2. A potential evolutionary trend in the latter part of the 1980-1990 decade is the transition from user-peculiar development of these algorithms to their routine use--after the necessary confidence resulting from high "batting averages" will have been achieved.

Such an evolutionary development would open the ADS to the opportunity of providing a centralized algorithm processing function. Algorithms which reach fruition would be transferred to this function

TABLE 10.3

DATA SERVICE REQUIRENTS FOR THE WATER QUALITY DISCIPLINE

		POLLUTION TRANSPORT & DISPERSAL	POLLUTANT EFFECT ON BIOPROCESSES
DATA LOCATION	Data Catalog	■	■
	Data Dictionary	■	■
	Computer Search	●	●
DATA EDITING	Quality Control	●	●
	Data Sorting	●	●
REFOR MATTING	Form Conversion	●	●
	Code Conversion		
	Coordinate Conversion		
	Scale Conversion		
ASSEMBLY	Data Segment Preparation	●	●
	Data Set Preparation	●	●
DATA INTEGRATION	Single-Source Multi-temporal Data Registration	●	
	Single-Source Multi-temporal Data Merging		
	Multi-Source Uni-temporal Data Registration	●	●
	Multi-Source Uni temporal Data Merging		
	Data Gridding	●	●
	Data Overlay		
	Image Mosaicing		
SPECIAL PROCES SING	Radiometric Correction	●	●
	Geometric Correction	●	●
	Other		
DATA MGM'T	Data Archiving		
	Data Delivery	1 ●	1 ●
OTHER		2 ■	2 ■

■ High Value Data Service ● Desirable Data Service

Note 1: 1 Week for Tech. Transfer

Note 2: Comprehensive Data Documentation

for conventional processing; the researcher would retain the function of developing the newer generations of algorithms.

10.3 Implications of the ADS on the Water Quality Discipline

The analysis of user requirements for the Water Quality Discipline results in the following data-related findings:

- Current water quality users are adequately served by current data delivery times. Current delivery times for space data fall typically within the range of 2 weeks (EROS-fast) to 2 months (NSSDC).

- Inland and coastal water quality efforts are in general served well by auxiliary data services such as WATSTORE and STORET when adequate access capability is provided. Data access times for STORET can be less than 3 hours. Typical times are of order of 24 hours.

- Space product costs are not a significant barrier to researchers: however, user efforts are impacted by cost considerations brought about by the deficiencies of the current auxiliary data collection system, principal among which are:

    a) conventional sources of key auxiliary data do not provide updated or sufficiently documented data catalogs and directories;

    b) data quality is often questionable;

    c) adequate geocoding information is not provided in the catalogs.

- ADS must provide an efficient and cost effective access to the auxiliary data services such as STORET and WATSTORE. In addition to the obvious benefits of improving access to data essential to the calibration and evaluation of remotely sensed water quality data, the linkage to these conventional archives would probably foster increased cooperation between NASA and other agencies and organization, hence opening up a wider user base for satellite derived products.

- NASA users in the Water Quality Discipline are oriented towards satisfying the near-term requirements of "external" users.
- This external user orientation strongly suggests that archival storage of system-corrected, parameterized and georeferenced data be made available. To meet these requirements, continuously updated and pedigree-annotated data catalogs and directories should be made available. This capability will significantly improve the data delivery to users and aid in providing integrated data sets required due to the complexities of the chemical, biological and hydrologic phenomena involved. It is most likely that common format data sets will be required in the future, probably in accordance with the USGS quad sheets.
- The reconnaissance nature of the Water Quality Discipline also make its advantageous to provide an archive of processed intermediate products both to support multiple investigations and for historical analytic purposes.

In Summary, the principal impact of an ADS upon the users of the Water Quality Discipline would be economic, i.e. significant reduction of time and monies spent by researchers to generate integrated data sets.

Three key functions would promote increased efficiency. In approximate priority:

- A comprehensive data catalog with georeferencing and data pedigree
- Enhanced access to auxiliary data sources
- Establishment of an archive for OSTA developed information products to support multiple investigations and to provide data feedbacks

11.1 Description of Objectives and Content

The statutory responsiblity for US Government activities oriented to agriculture, animal husbandry and forestry resides with the USDA, which explicates them through its Services.

The principal USDA Services, and the Federal Agencies principally concerned with domestic and foreign agricultural information, and their principal roles are:

SERVICE OR AGENCY	FUNCTION OR INTEREST
USDA - ESCS	Periodic domestic acreage inventory Periodic domestic yield estimation Periodic domestic production forecast Economic studies, domestic & foreign
USDA - FAS	As above, foreign producers As above, world estimate
USDA -ASCS	Periodic Land Use to assess farmer's compliance with price support and conservation policies
USDA - SEA	Research on improved agripractics
USDA - SCS	Assessment & Planning of irrigation policies
USDA - FS	Forest Inventories
FCIC	Verification of agricultural losses, assessment of premiums
OEP	Assessment of agridisasters for relief policy
AID	Assessment of recipients of Foreign Aid
Intelligence Community	Assessment of Foreign Agristatus

Currently, major interest for applying remotely sensed data lies within the Federal community charged with domestic and foreign crop inventory and forecast. This is because staple crops are a major element in the U.S. balance of payments, and in the formulation of U.S. foreign policy, in view of the relatively precarious world food situation.

The function of crop inventory and forecasting provides two types of outputs:

- statistical information
- economic intelligence

The first supports U.S. private traders, States, Counties, International Agencies, friendly countries. The second assists the Federal crop insurance program, U.S. planning agencies. OEP, the AID, U.S. intelligence functions.

Interest in applying remotely sensed data is growing within the segment of the USDA and of other Federal agencies charged with improving agricultural, husbandry and forestry techniques, e.g. irrigation, pollution abatement, alleviation of the adverse effects of weather and climate. These involve principally USDA's SEA, SCS, FS, and the DOI and NOAA.

OSTA's Agriculture Forestry and Rangeland Discipline supports the activities of the Agencies through a program whose objective is the utilization of remotely sensed data to address agricultural information needs.

Current OSTA Program

OSTA's efforts comprising the Agriculture, Forestry and Rangeland Discipline Program fall into eight categories of R&D Activities. These are identified in the joint USDA/NASA/USDI/NOAA AgRISTARS program.

AG 1 Early Warning/Crop Condition Assessment

Development of techniques to identify crop conditions which may provide early warning of significant changes in yield.

Infield damage destroys a substantial percentage of world staple crops each year. Its reduction through early detection can potentially add significantly to the world's food supply.

Early identification of crop stress, such as from disease or insect infestation, often allows timely remedial treatment to save yield.

AG 2 Foreign Commodity Production Forecasting

Development and test of techniques to provide objective and reliable crop production forecasts during the growing season, and improved preharvest estimates for several countries and staple crops.

Commodity production forecasts play a key role in determining crop prices on world markets. Accurate forecasting is expected to help stabilize these markets by allowing more precise and timely adjustments to surplus, or shortfalls of agricultural staples.

AG 3 Yield Model Development

Implementation of multi-variate models to predict growth conditions and to forecast yield for specified crops; development of physiological models which associate plant processes with observables, utilizing weather data, to estimate yield.

Improved yield models are critical to improving the accuracy of commodity forecasts.

AG 4 Supporting Research

Development of sensors and information extraction techniques to provide meaningful data to investigators of agricultural applications of remote sensing, in particular to support the information needs of the U.S. Department of Agriculture.

AG 5 Soil Moisture

Development and demonstration of technology to estimate soil moisture profiles from remote multisensor and ancillary data.

The proper level of soil moisture is crucial to normal crop development. Deficient or excessive levels exert stress on the crop resulting in decreased yield. Soil moisture is thus a significant variable in crop estimation.

AG 6 Domestic Crops and Land Cover

Development and implementation of an integrated satellite/ground monitoring system for more precise, cost-effective, and timely U.S. crop acreage and land cover estimates.

Accurate acreage estimates are essential to reliable crop forecasts. Variation of land cover with time indicates the amount and usage of arable land. This information is needed for the effective management of land productivity.

AG 7 Renewable Resources Inventory

Development and evaluation of techniques to apply remote sensing technology to the inventory, assessment, monitoring and management of forests and rangelands.

Provision of accurate information on the extent and condition of forests and ranges assists their management, hence this will help assure the continued availability and productivity of these resources.

AG 8 Conservation and Pollution

Development and evaluation of an integrated capability -- from satellite, aircraft, ground data -- to supply information on conservation, agricultural, forestry practices; to determine their effectiveness and to assist in eliminating the impact of pollution on production potential.

Erosion is a leading factor in reducing arable land. Identification of lands vulnerable to erosion, and assessment of anti-erosion practices, are promising areas of research to reduce the loss of agriculturally productive land. The deleterious effect of airborne pollution on vegetation is well recognized. The full impact of specific pollutants on crop yield, however, is not yet well understood. Research can contribute to improved yield forecasts, perhaps to the development of measures to reduce crop damage.

Near Future Program

The goal of OSTA's the near term Agriculture, Forestry, Rangeland Discipline Program is to support the AgRISTARS, Program. Its elements are:

- Early Warning and Crop Condition Assessment (EW/CCA)

  The USDA/FAS-CCAD's current proto-operational capability for early warning and crop condition assessment is expected to become operational in the 1980-1985 period. The related RD&T effort will be directed toward developing techniques compatible with this operational system.

- Foreign Commodity Production Forecasting (FCPF)

  Research oriented toward discrimination of wheat and barley in the presence of other small grains; extension of the commodity production forecasting to additional crops and regions; improvements in early season production estimation techniques using Landsat-D Thematic Mapper data.

- Yield Model Development

  Investigation of crop yield modeling based on: identification and measurement of the observables that relate to plant growth integration of their relationships with economic and technological drivers of crop yield, particularly for the small grain staples.

- Supporting Research

  Augmentation of existing technology, primarily for foreign commodity production forecasting.

- Soil Moisture

  Continue development and demonstration,on a limited scale, of technology to estimate soil moisture profile, based on remotely sensed data plus generally available ancillary data. Relationships between surface zone soil moisture and soil color will be used with the existing classification and mensuration systems to decrease intrafield cluster variance.

- Domestic Crops and Land Cover

  It is anticipated that USDA/ESCS's operational activities will employ remotely sensed data as an important adjunct to its primary data sources. The USDI/BLM is expected to initiate an operational wildland vegetation inventory system based upon the experience gained in the current Application Pilot Test. The cotton inventory APT is also anticipated to become operational in the 1980-1985 time frame.

- Renewable Resources Inventory

  The USDA Forest Service forest inventory APT, is expected to become an operational program. At the successful conclusion of the St. Regis Paper Company's forest stand inventory APT, the Company plans the development of an operational capability.

- Conservation - Pollution

  Evaluation of remote sensing techniques for assessing conservation practices and determining the impacts of pollutants on the environment.

Future Program

The Program's principal features are expected to be:

- NASA's Charter for technology development will remain unchanged.
- The AgRISTARS Program goals will be met approximately when due.
- The general scope of AgRISTARS will remain substantially unchanged.
- Space flight programs will proceed approximately in accordance with NASA's current plan for Landsat D, regardless of whether the operational charter is transferred to another Sister Agency.
- The growth of users beyond the AgRISTARS community will not significantly impact the program's data load.

The anticipated activity thrusts of OSTA's future program's are:

- AgRISTARS research results will lead to expanded activity in predictive model development. Qualitative and quantitative data interpretation techniques developed under AgRISTARS will be applied operationally. Research to develop optimum MRS bands for assessing episodic events will be initiated.
- Foreign Commodity Production Forecasting

  Foreign crop inventory technology development will focus on the optimal utilization of MRS to extend coverage into densely cultivated agricultural regions. MRS sampling, aggregation and observation strategies will be validated in OERS. A global inventory will be demonstrated.
- Yield Model Development

  New flight programs will promote (a) the optimum use of MRS channels to enhance the accuracy and stability of spectrometric models; (b) the integration of Soil Moisture Mission and Thermostat data, or equivalent, to enhance the applicability of yield models to abnormal growing conditions; (c) the application of System-85 soundings and improved weather forecasts to develop long-range yield predictors.

- Supporting Research

  Special attention will be given to (a) the evaluation of OERS, SMM and Thermosat sensors, to optimize their operational deployment; (b) development of multisensor data integration and information extraction techniques; and (c) research in the relationships between crop spectra and crop growth.

- Soil Moisture Estimation

  Investigations combining Soil Moisture SAT and Thermostat sensors, or equivalent, will continue to develop root-zone moisture profile estimators and to focus the development of wide-area surface-zone soil-moisture mapping systems. Soil moisture profile predictor models will be developed for application in further advancing early warning and yield prediction techniques.

- Domestic Crops and Land Cover

  Evaluation of optimum MRS bands for domestic crop inventory and mapping will lead to rapid extension of AgRISTARS area estimation capability to all 44 crop reporting states. Technology transfer will support decentralization to the State Statistical Office (SSO) level. Integration of early warning capabilities will enhance SSO's local area guidance capabilities. Developments in hydrological models and soil moisture estimation technology will promote the development of irrigation feedback control systems. The integration of land cover change detection techniques, conservation and pollution monitoring techniques, and improved area and yield estimators, supported by Geographic Information System (GIS) data bases, will lead to the development of a Land Productivity Management Information System.

- Renewable Resources

  OERS capabilities will improve forestry and rangeland inventory technology. The MRS will be for inventory used in a multistage sampling design integrated with the mapping capability of the TM. Large scale testing will validate system performance in fulfillment of Resource Planning Act's requirements.

- Conservation and Pollution

  Research will continue on systems for monitoring conservation conservation practices and for detecting and reporting pollution.

Figure 11.1 presents a graphic synopsis of OSTA's Agriculture/Forestry/Rangeland Program.

The first portion of the Figure reflects the space missions, current and projected, whose data products support the Program. The subsequent portion and continuation sheets reflects the Program's endeavors for each identified R&D Activity.

Each element is referenced to its pertinent source documents; their titles are listed at the Figure's end.

11.2 Relationships between Data Services and the Agriculture/Forestry/Rangeland Discipline

Figure 11.2 summarizes the requirements for data products expressed by the users.

FIGURE 11.1

AGRICULTURE/FORESTRY/RANGELAND DISCIPLINE TIMELINE

OSTA MISSIONS

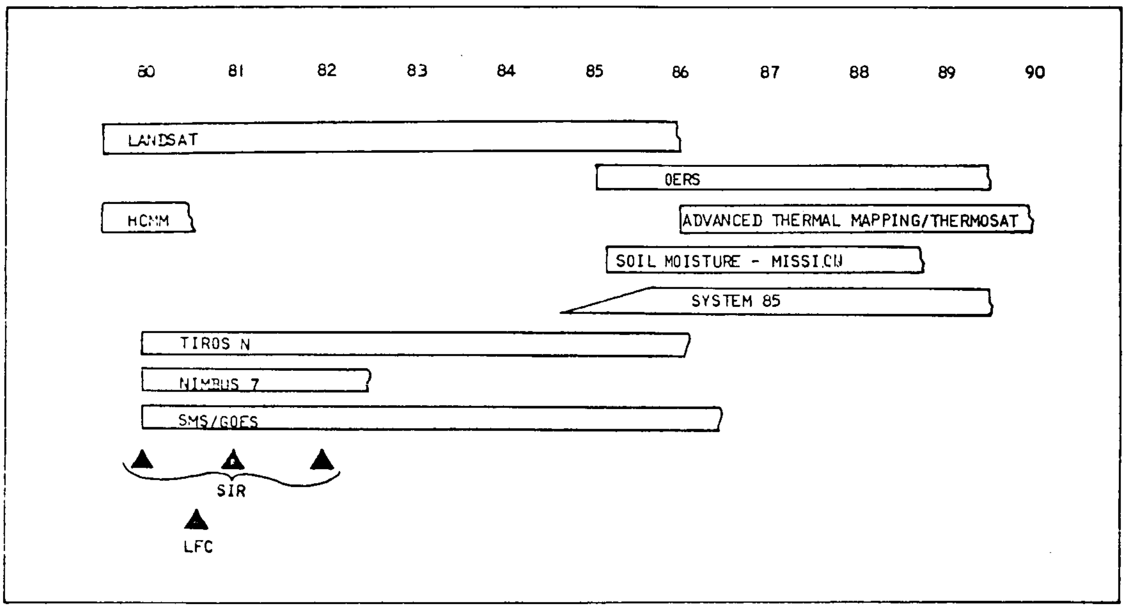
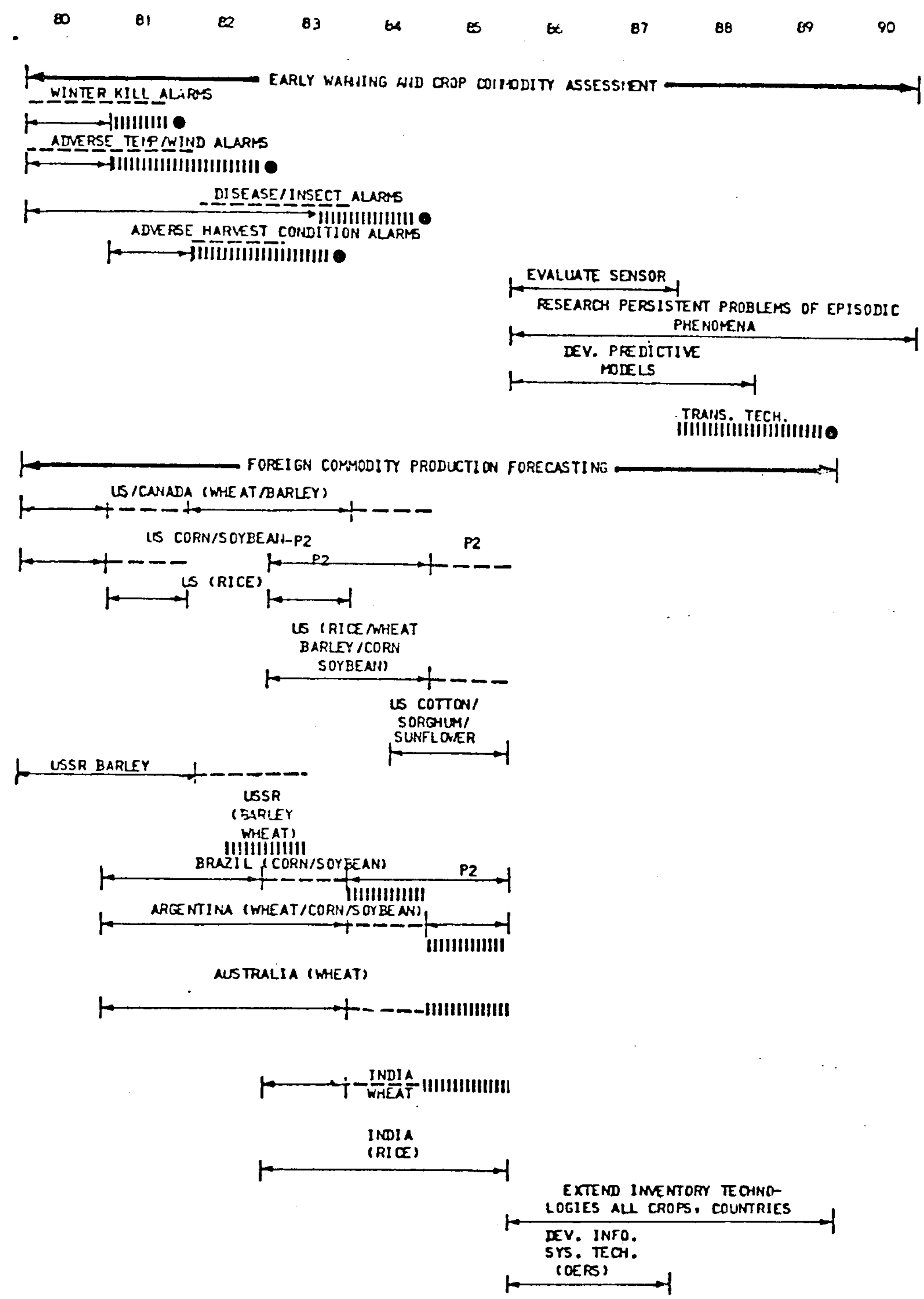


FIGURE 11.1

AGRICULTURE/FORESTRY/RANGELAND DISCIPLINE TIMELINE
R & D ACTIVITIES



REFERENCES AND LEGEND FOUND ON THE THIRD PAGE

FIGURE 11.1

AGRICULTURE/FORESTRY/RANGELAND DISCIPLINE TIMELINE (CONT'D)

R & D ACTIVITIES

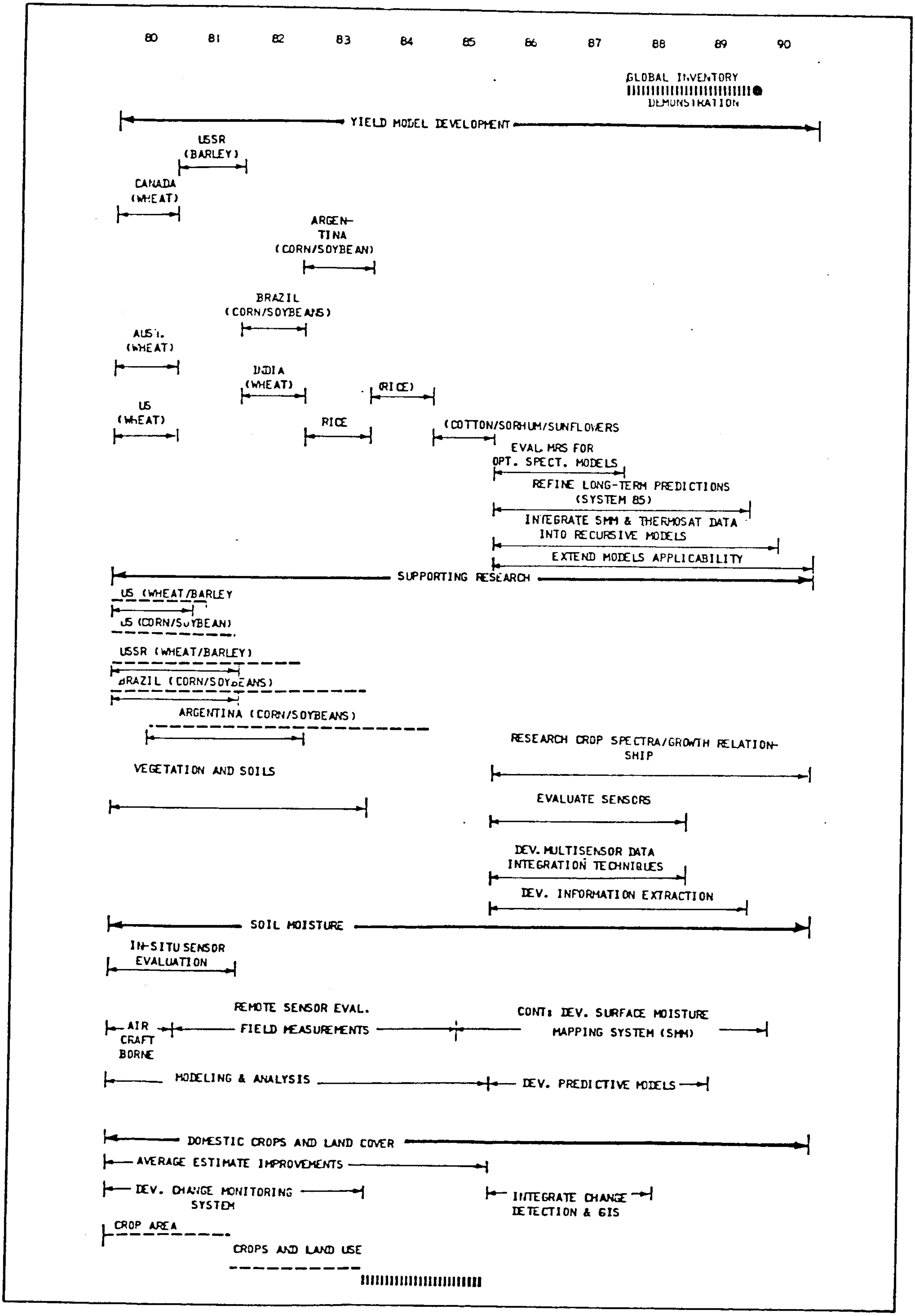
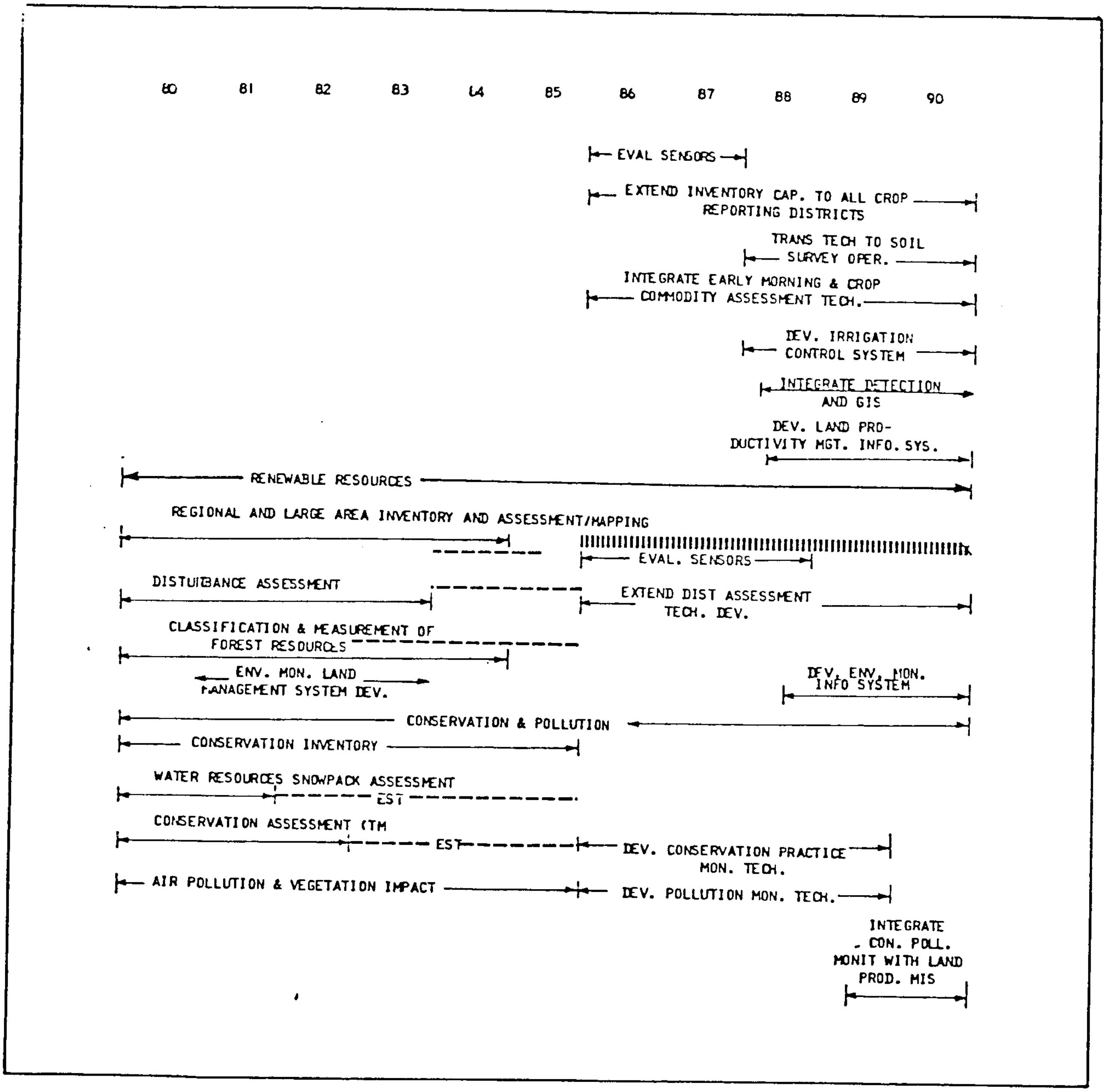


FIGURE 11.1

AGRICULTURE/FORESTRY/RANGELAND DISCIPLINE TIMELINE (CONT'D)

R & D ACTIVITIES



REFERENCES: COMPILATION OF JSC'S "PRELIMINARY TIMELINE OF AGRISTARS ACTIVITIES (1980-1985)" AND "PROJECTED TIMELINE OF AGRICULTURE, FORESTRY & RANGELAND ACTIVITIES FOR 1985-1990", ADS USER/PRODUCER REQUIREMENTS FOR AGRICULTURE FORESTRY AND RANGE 1980-85 AND 1985-90 APPLICATIONS SCENARIOS AND DATA REQUIREMENTS SUMMARIES, 1979.

LEGEND

1 Flight Mission
2 Program Emphasis
3 R&D Activity
4 Continuing Activity
5 Technology Transfer (Pilot/Application Tests Etc.)
6 Short Term Event
7 Initial Operational Capability
8 All Investigation Classes

FIGURE 11.2

USER REQUIREMENTS FOR SPACE DATA PRODUCTS, AGRICULTURE/FORESTRY/RANGELAND DISCIPLINE

	NOAA	NIMBUS 7	GOES	LANDSAT C		TIROS 'N		LANDSAT D		AEM 1	SHUTTLE		OERS		THERMOSAT	SYSTEM 85		SOIL MOISTURE SAT.			SHUTTLE	
PARAMETERS	AVHRR	SMMR	VISSR	MSS	RBV	AVHRR	TOVS	MSS	TM	HCMR	LFC	SIR	MRS	TM	AHCMR	AVHRR-FOLLOW	VISSR-FOLLOW	SAR	MPMR	AMS	ERSAR	
SURFACE TEMPERATURE	●	●	●			●				●					○	○	●		○			
WIND SPEEDS		●																				
PRECIPITATION RATE		●																				
SOIL MOISTURE		●								●		●			○			○	○	○	●	
SNOW COVER	●	●	●	●	●	○		○	●	●	○	●	●	●	○	○	○	○	○	○	○	
SOLAR RADIATION						MEASURED BY AIRCRAFT SENSORS																
AIR TEMPERATURE PROFILES							●															
LAND ALBEDO						○																
LEAF AREA INDEX				●	●			○	●	●			○	●	○							
MULTISPECTRAL CROP REFLECTANCE				●	●			○	●				○	●								
INSOLATION																						
CANOPY TEMPERATURES	●	●	○			○				●					○	●	○		○			
SOIL TEMPERATURES	●	●	○			●				●					○	○	○		○			
SURFACE WATER EXTENT	○	○	○	●	●	○		○	●	●	○	○	○	●	○	○	○	○	○	○	●	
PARTICULATE MEASUREMENTS						MEASURED BY AIRCRAFT SENSORS																
OXIDENT MEASUREMENTS						MEASURED BY AIRCRAFT SENSORS																
DATA BANKS																						
NOAA/NESS	●		●			○	○									○	○					
NCC/SDS			○			○										○	○					
EROS				●	○			○	●		○	●	○	●							●	
NASA/JSC GADB								○														
NSSDC		●								●	○				○			○	○	○	●	
GSFC/IPD										●												
JAWF			●																			
PRODUCTS																						**PRODUCT TOTALS**
1980 TAPES/YR.	45	360	270	3441	480	270	90	780	2460	1107	-	5	-	-	-	-	-	-	-	-	-	9308
1980 TAPE SEGMENTS/YR.	-	-	-	6380	280	-	-	-	1500	-	-	-	-	-	-	-	-	-	-	-	-	8160
1980 IMAGES/YR.	-	-	-	13654	1160	-	-	-	-	-	975	230	-	-	-	-	-	-	-	-	-	16019
1980 IMAGE SEGMENTS/YR.	-	-	-	400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	400
1980 OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1980 G BITS/YR.	1	13	9	123	17	9	3	27	87	39	-	0.2	-	-	-	-	-	-	-	-	-	329
1985 TAPES/YR.	-	[illegible]	225	180	280	270	90	2216	3889	862	-	5	-	-	-	-	-	-	-	-	-	8017
1985 TAPE SEGMENTS/YR.	-	-	-	-	280	-	-	1500	785	-	-	-	-	-	-	-	-	-	-	-	-	2565
1985 IMAGES/YR.	-	-	-	-	360	-	-	1627	307	-	565	230	-	-	-	-	-	-	-	-	-	3089
1985 IMAGE SEGMENTS/YR.	-	-	-	-	-	-	-	-	400	-	-	-	-	-	-	-	-	-	-	-	-	400
1985 OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1985 G BITS/YR.	-	-	8	6	10	9	3	78	136	33	-	0.2	-	-	-	-	-	-	-	-	-	283
1990 TAPES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	13084	20106	5400	2840	800	2240	2300	1750	120	48640
1990 TAPE SEGMENTS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	1360	280	-	-	-	-	-	-	1640
1990 IMAGES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	1306	6300	-	-	-	-	-	-	140	7746
1990 IMAGE SEGMENTS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1990 OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1990 G BITS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	459	704	189	99	28	78	81	61	4	1702

Users are primarily interested in obtaining parameters. These are intermediate information products derived from sensor measurements, elaborated via the application of appropriate algorithms. For example, soil temperature information derives from remotely sensed radiance data elaborated in conjunction with surface emissivity, soil moisture, atmospheric absorption, sensor calibration data

NASA users in the Agriculture Discipline are in the process of developing such algorithms. For this purpose, they wish to receive raw space data, augmented by the auxiliary data summarized in Table 11.1.

The volume of required space data shows a large increase through the 1980-1990 decade, from approximately 300 to 1,700 Gigabits/year. The volume required of auxiliary data, from Table 11.1 is approximately one-seventh that of the space data.

From Figure 11.1, OSTA's program is devoted to both research and technology transfer efforts throughout the 1980-1990 decade. Table 11.2 shows that the acceptable time lapse of data delivery for research of order one to four weeks.

Technology transfer activities acquire two forms: 1) algorithms and models developed by NASA researchers are tested by other federal agencies upon their facilities; or 2) they are tested on NASA facilities with participation from sister agency personnel.

The first form of transfer does not impact ADS because by current definition, ADS is intended to service NASA researchers only. In the

TABLE 11.1

USER REQUIREMENTS FOR AUXILIARY DATA PRODUCTS, AGRICULTURE

TYPE OF DATA	DATA PRODUCT FORMAT	SOURCE	ESTIMATED YEARLY PRODUCT VOLUME*									USE OF DATA PRODUCT
			AG 1	AG 2	AG 3	AG 4	AG 5	AG 6	AG 7	AG 8	TOTAL	
Meterologic Data	Daily weather reports from ground stations and monthly summaries of wind speed, temperature, humidity cloud cover and precipitation available on digital tape (800 BPI)	EDIS (NMC, NCC) JAWF	1081	541	405	1351	1216	2162	2703	541	10,000	Input to crop growth model for estimated of yield/ crop condition and provide information required for identifying high potential areas for crop disease/pest infestations
Historical Meterologic Data	Historical summaries of drought, freeze events, dessication, severe weather and floods provided on magnetic tape (800 BPI)	EDIS (NCC)	80	40	30	-	-	-	-	-	150	Calibration for probalistic weather forecast schemes for input to long term crop yeild models
Solar Radiation Data	Measurements of daily and hourly solar radiation for the U.S. recorded on 9 track digital (1600 BPI) tape	EDIS (NCC)	80	40	30	1000	-	-	-	-	1,150	Input to crop growth model for extimation of yield
Soils Data	Soils maps of soil type, aerial extent and zonal depth available (1:25,000 scale) map	USDA (CMC)	160	80	60	200	280	320	400	80	1,580	Inputs to crop growth models
Topographic Data	9 track digital tape (1600 BPI) with information on elevation slope and aspect	NCIC	32	16	12	40	36	64	80	16	296	Derived parameters of slope and aspect are used to make radiometric corrections to remotely sensed data
	Topographic map of elevation slope and aspect (1:250,000 scale)		160	80	60	200	280	320	400	80	1,580	

*Voulme specified in number of individual products (Tapes, maps, reports...)

TABLE 11.1

USER REQUIREMENTS FOR AUXILIARY DATA PRODUCTS, AGRICULTURE (CONT.)

TYPE OF DATA	DATA PRODUCT FORMAT	SOURCE	ESTIMATED YEARLY PRODUCT VOLUME*									USE OF DATA PRODUCT
			AG 1	AG 2	AG 3	AG 4	AG 5	AG 6	AG 7	AG 8	TOTAL	
Geopolitical Data	Geopoliticalmaps (1:5,000,000 scale) delineating boundaries of CRD's and foreign equivalent subdivisions	USDA (CMC) NCIC	80	40	30	-	-	-	-	-	150	Provides baseis for guiding Agricultural sampling schemes
Crop Spectra Data	Crop spectra measurements and supporting ground infomration on low density (800 BPI) tape	LARS, GISS, WESLACO, TAMU	16	8	9	20	-	-	-	-	50	Carefully collected crop spectra data corresponding to well documented surface conditons are used to develop interpretation schemes for relating remotely sensed data to crop condition and stage
Historical Yield and Production Data	(800 BPI) digital tape containing historical yield and production statistics by crop (U.S. - 1 tape/state, Non U.S. - 1 tape/country	USDA (ESCS)	80	40	30	-	-	-	-	-	150	Calibration of satellite base yield and production models
Evaporation Data	Digital (800 BPI) tape of pan evaporation data	EDIS (NCC)	24	12	9	30	27	-	-	-	102	Estimation of evaporation/evapotranspiration rates for input to and crop growth models
Soil Moisture Data	Digital low density (800 BPI) tape of lysimeter data	EDIS (NCC)	24	12	9	30	27	-	-	-	102	Verification of SMMR, SAR, HCMR, etc. soil moisture measurements

*Volume specified in number of individual products (Tapes, maps, reports....)

TABLE 11.2

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS:

AGRICULTURE, FORESTRY, RANGELAND

(OBSERVATIONS)

	R & D ACTIVITY							
	EARLY WARNING/CROP CONDITION ASSESSMENT	FOREIGN COMMODITY PRODUCTION FORECASTING	YIELD MODEL DEVELOPMENT	AGRICULTURE PROGRAM SUPPORTING RESEARCH	AGRICULTURE SOIL MOISTURE PROJECT	DOMESTIC CROP AND LAND COVER ESTIMATION	RENEWABLE RESOURCE INVENTORY	AGRICULTURE CONSERVATION & POLLUTION PROJECT
REQUIREMENTS	AG 1	AG 2	AG 3	AG 4	AG 5	AG 6	AG 7	AG 8
Horizontal Resolution (KM)								
Minimum	0.03	0.03	0.06	0.03	0.03	0.03	0.03	0.03
Maximum	10	0.1	0.1	0.1	0.1	0.1	0.1	50
Modal	1-10	0.5-0.1	0.06-0.01	0.03-0.1	0.03-0.1	0.03-0.1	0.03-0.1	50
Vertical Resolution (KM)								
Minimum	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Maximum	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Modal	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Frequency								
Minimum	9 Days	73 Days	4 Weeks	3 Mo.	1 Yr.	1 Yr.	4 Mo.	9 Days
Maximum	1 Day	73 Days	1 Day	1 Mo.	3 Mo.	3 Mo.	2 Mo.	9 Days
Modal	1-9 Days	73 Days	1 Day	3 Mo.	3-12 Mo	3-12 Mo.	2-4 Mo.	9 Days
Data Delivery								
Research Investigations	4 Wks.	1-4 Wks	4 Wks.	4 Wks.	4 Wks.	4 Wks.	4 Wks.	9 Days
Technology Transfer	2-4 Days	1-2 Wks	1 Wk.	N.A.	1 Wk.	4 Wks.	1-2 Wks.	1-2 Wks

TABLE 11.2 (cont'd)

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS
AGRICULTURE, FORESTRY, RANGELAND

(SPECIAL SERVICES)

REQUIREMENTS	R & D ACTIVITY							
	AG 1	AG 2	AG 3	AG 4	AG 5	AG 6	AG 7	AG 8
Provide Georegistered Segment Mini-Tapes	X	X	X					
Scene to Scene Registration	X						X	X
Meteorological Parameters Portrayed on Contour Maps (1% Accuracy) Overlayed on 12.5 Nm Grid	X							
Remotely Sensed Data formatted to User Specifications	X	X		X	X	X	X	
Geometric Correction of Remotely Sensed Imagery	X							
Geocoded Auxiliary information	X							
Collect Georeferenced & File Agronomic Data on Standard Referenced Grid	X							
Space Data Calibration Geometric Referencing, Registration	X	X		X	X	X		
Georeference and Register CCT and Photographic Producta		X						
Catalog index Query and Central Referral Services		X		X			X	
Organize Auxiliary Data by Location, Date, on 12.5 Nm Grid or by Segment								
Vissr Data must be Formatted into Usable Tabular & Graphic Formats			X					
Maintain a Catalog and Dictionary of Remotely Sensed Data			X					
Collect and Provide Collelary Agronomic and Meterological Data in Georeferenced Data Sets			X					

TABLE 11.2 (cont'd)

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS:
AGRICULTURE, FORESTRY, RANGELAND

(SPECIAL SERVICES)

	R & D ACTIVITY							
REQUIREMENTS	AG 1	AG 2	AG 3	AG 4	AG 5	AG 6	AG 7	AG 8
Calibration, Geometric Correction, Geometric Registration, of Max-Min. Temperature Observation, Interpolated to Common Grid Sites			X					X
Resample and Georeference Auxiliary Data				X				
Provide Multisensor Data Merging and Registration				X			X	
Provide Mini-Tapes of (OSTA DAT)				X				
Digitize Ground Truth & Field Measurements in Common Format and Record on Tape File				X	X			
Disparate Aircraft & Satellite Data must be Registered Together to a Common Format					X			
Provide Cloud Masking Procedures						X		
Provide Digital Terrain Data Registered to Space & Aircraft Data							X	
Locate and Supply Required opographic and Soils Maps								X
Provide Cloud Free CCT'S For Conservation Inventory Studies								X

TABLE 11.2 (cont'd)

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS
AGRICULTURE, FORESTRY, RANGELAND
(STANDARD ALGORITHMS)

TABLE 11.2 (Cont'd)

	R & D ACTIVITY							
REQUIREMENTS	AG 1	AG 2	AG 3	AG 4	AG 5	AG 6	AG 7	AG 8
Soil Moisture Estimator	X				X			
Normal Condition Image Masks	X							
Crop Type Classification	X	X			X			
Crop Stage Estimator		X						
Crop Stress Estimates	X	X					X	
Degree Day Estimator			X					
Crop Yield Estimator			X					
Radiometric Calibration Classification Techniques	X	X	X	X				
Five Search, Sort and Retrieve Generation		X		X				
Improved Crop Calendars		X						
Area Specified Yield		X						
Geometric Corrections			X					
Registration Algorithms			X	X		X	X	X
Multi-spectral Classification Special Transforms (Tacap, Vien, etc)				X				
Calibration Algorithms					X	X	X	X
Area Mensuration						X		
Land Cover Change Detector						X	X	
Maximum Likelihood Land Use Cover Classifier								
Statistical Analysis of Ground Truth Via Supervised and Unsupervised Classification Algorithms						X		
Vegetation Type Classifier							X	X
Soil Type Classifier							X	
Vegetation Canopy Density							X	
Scene Reflectance Corrected to Compensate Terrain							X	
Aspect and Elevation							X	
Vegetation Condition Estimator								X
Erosion Potential Estimator								X

second event, the timeliness requirements for data transfer are of order a few days.

Thus, ADS data transfer requirements for research activities can be satisfied by a service of data rate comparable to that of the U.S. mail.

AgRISTARS technology transfer activities will be performed in large measure on facilities which, although in part jointly owned by the AgRISTARS participants. They would thus fall within the purview of an ADS system.

The slow data delivery requirements inherent in the research activities not necessarily connote that electronic linkages are not desirable. They simply indicate that the choice of the link is driven by economic cost-effectiveness rather than by technical urgency. For example, a plausible ADS scenario may well incorporate a centralized accounting, scheduling and data traffic monitoring facility; which maintains track of expenditures on the part of the users, supplies them budgetary estimates, advises them of impending depletion of project funds. Further analysis might reveal that such centralized management function can be performed more cost-effectively through use of electronic data links than through other conventional alternatives; quite apart from considerations of speed.

As a gross sizing of the "electronic link" alternative for the "slow" R&D Activities, the corresponding transfer requirements are such as to engage the equivalent of approximately 63 data links of 1,200 bps capacity each, operating on a one shift, normal work week basis for the current and near term programs; growing to 326 equivalent links in the 1985-1990 time frame.

Because the driver of the "slow" activities is economics, not technology, system tradeoffs can exploit to the fullest special tariff structures and price breaks: e.g. discounts for off-time operation, quantity savings from use of bulk bandwidths, use of satellite links whenever transfer distance exceeds the cost breakpoint (currently of order 900 kilometers).

The need for fast data transfer links becomes more pressing for technology transfer activities. The activities posing the most stringent requirements are early warning, and activities associated with crop production forecasting.

The timings of the corresponding physical observables are such as to give rise to short periods of intense interest, interspersed by longer intervals of lesser importance. The occurence of frosts is a typical case in point: indicative crop change within hours, at most a few days after the frost event; thereafter the "indicators", pointing to either recovery or loss, vary but slowly.

The net result is that these activities impact ADS by imposing conditions of high peak transfer rates at low duty cucles. As a gross sizing, peak-to-average ratios are expected to reach 5:1.

ADS systems tradeoffs can exploit the significant difference between the "slow" R&D and the "fast" Technology Transfer requirements through the use of load-evening techniques, such as priority scheduling.

Analysis of Tables 11.3 and 11.2 permits the inference that user services related to imagery manipulation -- e.g. geocoding, superposition of formats, gridding -- willimpose very significant technological requirements upon ADS. This is because quite high spatial resolutions are needed to satisfy the users.

Users need to have available in excess of 50 significant types of algorithms, Table 11.2. A potential evolutionary trend in the latter part of the 1980-1990 decade is the transition from user-peculiar development of these algorithms to their routine use -- after the necessary confidence resulting from high "batting averages" will have been achieved.

Such an evolutionary development would open the ADS to the opportunity of providing a centralized algorithm processing function. Algorithms which reach fruition would be transferred to this function for conventional precessing: the Researcher would retain the function of developing the newer generations of algorithms.

DATA SERVICE REQUIREMENTS FOR AGRICULTURE, FORESTRY, RANGELAND DISCIPLINE

		EARLY WARNING OF CROP CONDITION	FOREIGN COMMODITY PRODUCTION	YIELD MODEL ASSESSMENT	SUPPORTING RESEARCH	SOIL MOISTURE	DOMESTIC CROP LAND USE	RENEWABLE RESOURCE INVENTORY	CONSERVATION AND POLLUTION
DATA LOCATION	Data Catalog	■	■	■	■	■	■	■	■
	Data Dictionary	■	■	■	■	■	■	■	■
	Computer Search								
DATA EDITING	Quality Control								
	Data Sorting	●	■	●	■	●	●	●	●
REFORMATTING	Form Conversion								
	Code Conversion								
	Coordinate Conversion								
	Scale Conversion	●	●	●	●	●	●	●	●
ASSEMBLY	Data Segment Preparation	●	●	●	●	●	●	●	●
	Data Set Preparation	●	●	●	●	●	●	●	●
DATA INTEGRATION	Single-Source Multi-temporal Data Registration	●	●		●	●			●
	Single-Source Multi-temporal Data Merging								
	Multi-Source Uni-temporal Data Registration								
	Multi-Source Uni temporal Data Merging								
	Data Gridding								
	Data Overlay	●	●	●	●	●	●	●	●
	Image Mosaicing								
SPECIAL PROCESSING	Radiometric Correction						●	●	●
	Geometric Correction	●	●	●		●	●		
	Other								
DATA MGM'T	Data Archiving				■		●		
	Data Delivery								
OTHER		1 ■	2 ■	1 ■					

■ High Value Data Service ● Desirable Data Service

Note 1: Geocode Data
2: Georeference Data Products

11.3 Implications of ADS on the Agriculture, Forestry & Rangeland Discipline

Analysis of the user requirements for the Agriculture, Forestry and Rangeland Discipline results in the following data-related points.

- The users state that the major portion of activities in Agriculture, Forestry and Rangeland are adequately served by current data delivery times. Only a limited amount of data is currently required in near-real-time, specifically that for technology demonstrations under the AgRISTARS program, where timeliness of information extraction and/or utilization plays a significant role.

  The AgRISTARS MOU specifies that NASA activities should relate to the use of remote sensing for agricultural applications, e.g. early warning of events affecting production, and to the transfer of techniques to USDA for subsequent operational use. Demonstrations typically involve cooperative activity with USDA operational personnel. The real-time elements of data delivery are not generally within the purview of OSTA data systems.

  ADS can however play an important support role to technology demonstrations by speeding up current data delivery times to those required by the end user.

- Data cost issues were not identified as a major concern by the research users. Cost considerations were recognized as important issues in the eventual translation of the technology to an operational mode.

- A key conclusion drawn from Agriculture researchers is the need to obtain auxiliary data with greater efficiency. Currently, investigators gather their required data from a wide variety of basically unarchived and unannotated sources. Dealing with a variety of data banks is time consuming: the users universally express the need for a centralized facility from which they can locate and acquire the bulk of the data which they require.

  Agricultural remote sensing activities generally requires a long initial period of locating, ordering, acquiring, sorting, and registering data. These data sets contain observations, meteorological data, agronomic data, crop calendar data, yield data and maps. The auxiliary data requires extensive preparation and digitization or format alteration; the spacecraft data must be extracted and registered pass to pass or from one imaging system to another. The preparation of data sets has been found by the users to be as large if not larger job than the data analysis itself in terms of the time and money which must be expended.

- Two key functions, applicable to ADS, which can support the users efforts are:

  a) Data Documentation - *maintenance of a comprehensive continually updated catalog is required. This catalog should identify location and general content of the data, but additionally provide indications as to the quality of each datum.*

  b) Data Integration - This function entails elements of both data set preparation and reformatting. Potential processing operations required to convert disparate data to a common form and scale, suitable for input to classification schemes include:

- multi-sensor unitemporal and multitemporal registration, entailing the congruencing and rescaling of data of different scale and aspect angle;

- geographic referencing;

- coordinate transformations, for example space oblique mercator to universal transverse mercator;

- data overlay and gridding;

- mosaicking, in which adjacent swaths of space or airborne imaging sensors are equalized radiometrically, congruenced, rescaled, laterally registered and organized in a wide-area digital data file.

In summary, the principal impact of an ADS upon the users of the Agriculture, Forestry and Rangeland Discipline would be economic, i.e. reduction of the time and cost expenditures required by investigators to acquire the integrated data sets they require. Performance would also be enhanced by the improved data services offered by an ADS.

Four key functions would promote increased efficiency. In approximate priority:

- Provision of a comprehensive data catalog and directory for auxiliary data

- Data set preparation and reformatting services to facilitate data integration

- Centralization of data access

- Acceleration of data delivery times to support technology demonstrations

12.1 Description of Objectives and Content

Geodynamics combines aspects of geology, geophysics, and geochemistry. An international research program in geodynamics has grown up in the last twenty years mainly as a result of the formulation of the plate tectonics model of dynamic processes. International coordination is the responsibility of the Interunion Commission on Geodynamics of the International Council of Scientific Unions, whose present activities are embodied in the International Geodynamics project.

Within the United States a National Geodynamics Program was authorized by the Earthquake Hazard Reduction Act of 1977. Under this act Congress initiated a broad research program whose goal is to save lives and property by developing the capability to predict earthquakes possibly eventually to control them.

Primary responsibility for the program lies with the U.S. Geological Survey and the National Science Foundation.

The national earthquake hazard reduction program is oriented toward a comprehensive understanding of the dynamic processes that produce earthquakes. The practical objective is a prediction system based on well-understood physical principles so that reliable estimates can be made of the time, place, and magnitude of earthquakes.

The objectives of OSTA's Geodynamics Discipline Program is to support the U.S. national program in earthquake hazard reduction by studying dynamic processes related to earthquakes; and to support the ongoing international program of research in global geodynamics.

There are three major technology components in the OSTA's Geodynamics Program. The first is the use of interlocking networks of fixed and transportable laser ranging and VLBI stations to acquire regional-scale and global-scale data on small motions of the earth's crust. This information is of significance to basic research in global geodynamics and for meeting the objectives of the Earthquake Hazard Reduction Program.

The second component is the development of improved space techniques for measuring relative positions at large numbers of points in seismic zones, which may lead to much more complete monitoring of possible crustal movements than otherwise would be feasible. The third is the measurement of the earth's gravity field with sufficient accuracy to meet the needs of both basic research in global geodynamics and applications to the important field of physical oceanography.

Current OSTA Program

OSTA's efforts comprising the Geodynamics discipline fall into four categories of R&D activities

GD 1 Earth Dynamics

Earth Dynamics investigation employ space geodetic technqiues to improve the understanding of the dynamics of the earth through the development of models of polar motion and earth rotation, global tectonic plate motion, mantle convection and plate driving mechanisms, earth's core dynamics and solid earth tides.

Improved understanding of tectonic plate motions and their driving mechanisms is a key element in earthquake prediction and risk assessment. The mechanisms which drive the plates are still poorly understood; the continued development of concepts and models to explain plate motion has considerable scientific importance. Earth rotation and polar motion must be accounted for in the precise position determinations that are the major emphasis of space-related geodynamics and also have an important connection to the understanding and prediction of earthquakes. Earth tides must also be taken into account, since they perturb the motions of satellites. These perturbations of spacecraft must be accurately modeled so that spacecraft can be used for making geodetic measurements

GD 2 Earth Structure

Models are being developed, based on combined in-situ and space data to improve the knowledge and understanding of the global structure of the earth; its interior, crustal magnetism, gravity field anomalies and for the evolution of the earth's lithosphere and crust to map both continental and ocean bottom topographic features in order to derive lithospheric and mantle properties.

To better understand the processes that are taking place within the earth, it is necessary to obtain a more precise description of internal earth material and its properties such as density, viscosity and elasticity. Space derived data can provide constraints on such parameters; they may also provide information useful for the location of earth resources such as minerals and petroleum.

GD 3 Regional Crustal Deformation and Modeling

Modeling studies of crustal deformation related to the interpretation of space laser ranging and VLBI data are conducted to improve the understanding of fault motion, earthquake mechanisms, intra-plate stress and strain and subsidence and the relationship between stresses and strains and the magnitude of internal plate deformations and seismicity, and the effects of regional tectonism and fluid withdrawal on terrain subsidence. Space geodetic techniques are used to monitor vertical and horizontal crustal movements. Current research effort center upon describing earthquake properties such as rupture criteria and energy release, episodic and steady-state creep along faults.

These activities contribute to the understanding of the dynamic processes related to earthquakes and may improve our knowledge of mineral resource distributions and provide valuable information on the under standing and controlling of subsidence. They support both the U.S. national program in earthquake hazard reduction and the on-going national and international programs of research in global geodynamics.

GD 4 Geopotential Fields

Gravity and magnetic field models are being developed to support the other geodynamic research activities. Improved gravity field models are based upon high precision laser tracking data and satellite altimetry data. High resolution global geoid maps combining surface gravity and/or altimetry data with the gravity field derived through satellite tracking are being produced.

Gravity field and geoid contributes to basic understanding of the earth's interior structure, properties and composition; to our understanding of the location and formation of the planet's natural resources; and assist in the determination of temporal variations in the sea-surface topography related to ocean circulation and the interaction of the earth's atmosphere with the oceans. Internal gravity field models are used for many theoretical calculations and for constructing magnetic charts useful for navigation. Studies of its secular variation provide clues to the structure and dynamics of the earth's core and lower mantle. The magnetic anomaly field, together with correlative data, can be used to model the structure and composition of the crust.

Near Future Program

The program's philosophy is to perform research focusing or the study of the causes of earthquakes, with particular attention to regions where earthquakes are likely to occur; the description and explanation of tectonic processes, to explain the origin of features in the earth's gravitational and magnetic fields; the understanding of the origin and disposition of mineral resources, and the description and explanation of sea state, circulation, and other oceanic features.

The research elements of the near term geodynamics program are:

- development of simple regional strain accumulation models
- development of numerical/theoretical models of earth rotation
- analysis of regional geodetic measurements
- plate motion model development
- surface gravity data analysis and development of comprehensive global gravity field solutions
- systematic categorizing of world gravity anomalies
- development of global and regional ocean geoids accurate to 10 cm over oceans,, 30 cm over continents
- implementation of techniques for inversion of surface wave and travel time data, applications to models
- development of methods of delineating Curie isotherm levels from heat flow and satellite magnetic data
- feasibility studies for the gravity gradiometer
- evaluation of test site data for cryogenic gravimeter

Principal related technology development and utilization is in the following areas:

- mapping of the Wallops Island Flight Test Center (WFC) with AOL and SCR
- demonstration of a cost-effective crustal deformation monitoring technology in high earthquake hazard regions
- use of overland satellite altimetry from GEOS-3 as a systems demonstration for a selected subsidence area
- field test of TLRS
- initiation of the Polaris network of fixed VLBI observations
- development of a high accuracy analysis system for VLBI
- Procurement of a GSP-X data set for Wallops Island

Future OSTA Program

The goals of the future Geodynamics Discipline Program are:

- the continued development and improvements of VLBI and laser ranging techniques. These systems are needed to obtain polar motion and earth rotation data, and for determination of crustal movement. These data will be applied to studies of plate stability and to the refinement of plate tectonic models. Developed technology will be transferred to the National Ocean Survey
- improved interpretation of geopotential

- the development and use of fixed mobile VLBI and laser ranging techniques, These are needed for improved determination of crustal movement deformation and strain
- continued refinement of magnetic and gravity models

Figure 12.1 presents a graphic synopsis of OSTA's Geodynamics Discipline Program.

The first portion of the Figure reflects the space missions, current and projected, whose data products support the Program. Subsequent portion and continuation sheet reflects the Program's endeavors for each identified R&D Activity.

Each element is referenced to its pertinent source documents; their titles are listed at the Figure's end.

12.2 Relationships between Data Services and the Geodynamics Discipline

Figure 12.2 summarizes the requirements for data products expressed by the users.

Users are interested in obtaining parameters. These are immediate information products derived from sensor measurements, elaborated via the application of appropriate algorithms. For example, land elevation information derives from remote altimetry data elaborated statistically in conjunction with orbital parameters, atmospheric index of refraction, sensor calibration data.

FIGURE 12.1

GEODYNAMICS DISCIPLINE TIMELINE

OSTA MISSIONS

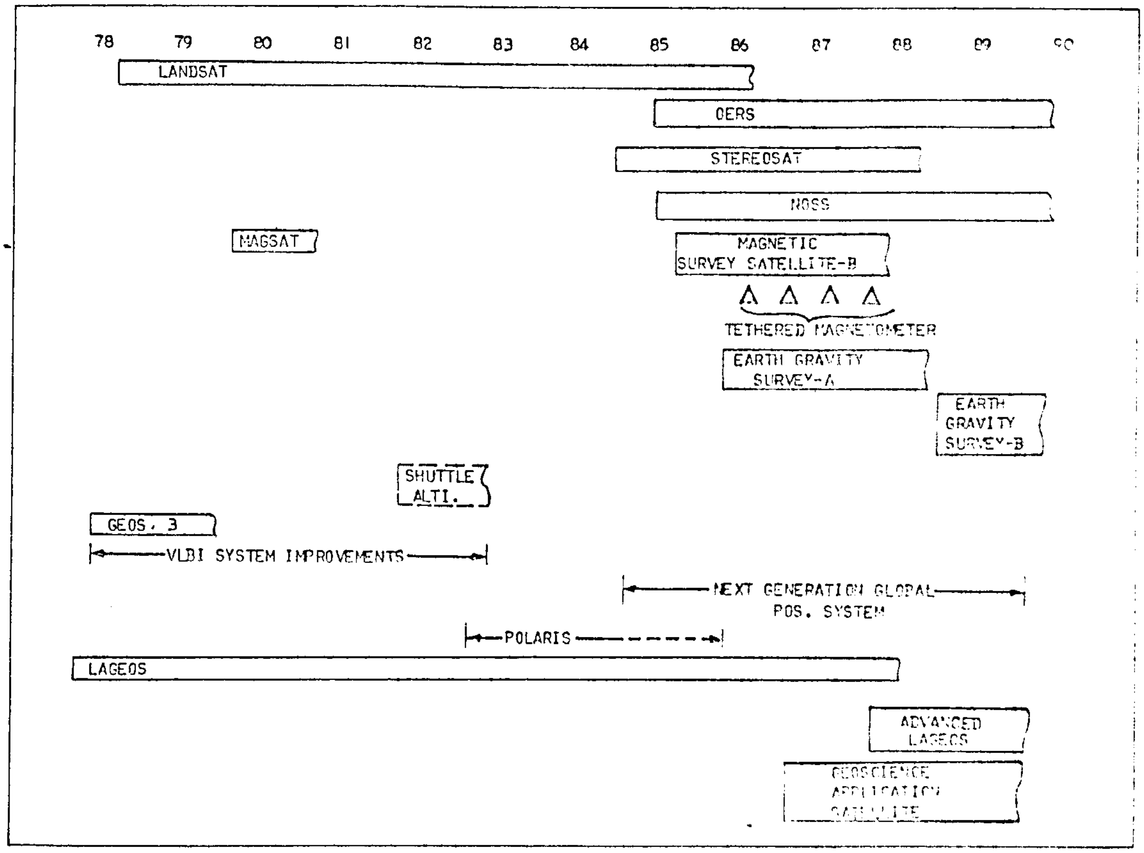
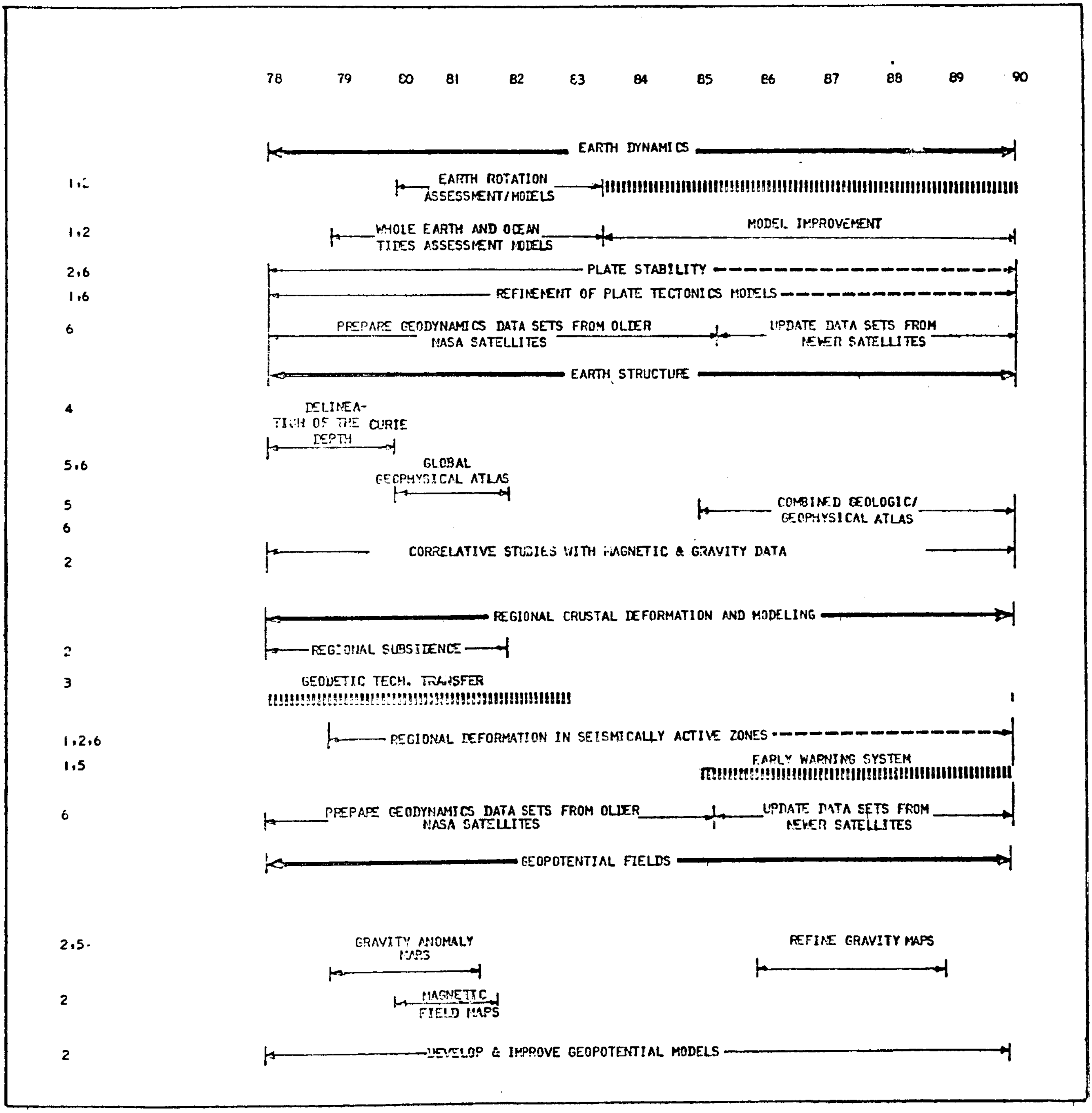


FIGURE 12.1

GEODYNAMICS DISCIPLINE TIMELINE
R & D ACTIVITIES



LEGEND

1 Flight Mission
2 Program Emphasis
3 R&D Activity
4 Continuing Activity
5 Technology Transfer (Pilot/Application Tests Etc.)
6 Short Term Event
7 Initial Operational Capability
8 All Investigation Classes

REFERENCES:
1) APPLICATION OF SPACE TECHNOLOGY TO CRUSTAL AND EARTHQUAKE RESEARCH, 1978
2) GEODYNAMICS PROGRAM RESEARCH PLAN, 1977
3) NASA GEODYNAMICS PROGRAM SUB-PROGRAM PLAND REVISED APRIL 78.
4) LASER GEODYNAMICS SATELLITE (LAGEOS) A.O. NO. OSTA 78-2, 1978
5) PROGRAM SCIENTIST CONFIRMATION
6) RESOURCE OBSERVATION 5 YEAR PLAN, FY 1981-85 PRESENTATIONS TO NASA PLANNING COUNCIL, 1979

FIGURE 12.2

USER REQUIREMENTS FOR SPACE DATA PRODUCTS, GEODYNAMICS DISCIPLINE

	VLBI SYSTEMS	SATELLITE TO SATELLITE TRACKING SYSTEM	LASER RANGING SYSTEM	GEOS	POGO	L-SAT	MAGSAT A	GRAVSAT A	NOSS	STEREOSAT	OERS		TOPEX	MAGSAT B	GRAVSAT B	SHUTTLE	
PARAMETERS	1	1	1	ALT	MAGNETOMETER	RBV	MAGNETOMETER	GRAVITY GRADIOMETER	ALT	STEREO TELESCOPE	MRS	TM	ALT	MAGNETOMETER	GRAVITY GRADIOMETER	MAGNETOMETER	
BASELINE LENGTH CHANGE	O		O														
GRAVITY FIELDS		O		O				O	O				O		O		
EARTH ROTATION PERIOD	O		O														
POLAR MOTION	O		O														
MAGNETIC FIELDS				O	O		O		O				O	O		O	
LINEAR SURFACE FEATURES						O				O	O	O					
LAND ELEVATION				O					O				O				
SEA SURFACE ELEVATION				O					O				O				
DATA BANKS																	
NSSDC		O	O	O	O		O	O					O	O	O	O	
NOSS/PPF									O								
GSFC/VLBI	O																
JPL/VLBI	O																
EROS						O				O	O	O					
PRODUCTS																	PRODUCT TOTALS
1980 TAPES/YR.	23	102	28	176	34	51	58	-	-	-	-	-	-	-	-	-	477
1980 IMAGES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1980 OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1980 G BITS/YR.	1	4	1	6	1	2	2	-	-	-	-	-	-	-	-	-	17
1985 TAPES/YR.	28	102	28	-	-	-	58	37	176	-	-	-	-	-	-	-	429
1985 IMAGES/YR.	-	-	-	-	-	-	-	-	-	51	15	15	-	-	-	-	81
1985 OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1985 G BITS/YR.	1	2	1	-	-	-	2	1	6	-	-	-	-	-	-	-	15
1990 TAPES/YR.	28	102	28	-	-	-	-	-	152	-	-	-	24	58	37	16	445
1990 IMAGES/YR.	-	-	-	-	-	-	-	-	-	51	15	15	-	-	-	-	81
1990 OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1990 G BITS/YR.	1	4	1	-	-	-	-	-	5	-	-	-	1	2	1	1	16

NASA users in the Geodynamics Discipline are in the process of developing such algorithms. For this purpose, they wish to receive raw space data, augmented by the auxiliary data summarized in Table 12.1.

The volume of required space data remains steady throughout the 1980-1990 decade, at approximately 15 Gigabits/year. The volume required of auxiliary data, from Table 12.1, is approximately one half that of the space data.

From Figure 12.1, OSTA's program is devoted to both research and technology transfer efforts throughout the 1980-1990 decade. Table 12.2 shows that the acceptable time lapse of data delivery for research activities is of order one to three months.

Technology transfer activities could acquire two forms: 1) algorithms and models developed by NASA researchers are tested by other federal agencies upon their facilities, in this case NOAA's; or 2) they are tested on NASA facilities with participation from sister agency personnel.

The first form of transfer does not impact ADS because by current definition, ADS is intended to service NASA researchers only. This is the mode envisioned for the Geodynamics Discipline Program.

ADS data transfer requirements can be satiafied by a service of data rate comparable to that of the U.S. mail.

The slow data delivery requirements do not necessarily connote that electronic linkages are not desirable. They simply indicate

TABLE 12.1

USER REQUIREMENTS FOR AUXILIARY DATA PRODUCTS, GEODYNAMICS DISCIPLINE

TYPE OF DATA	DATA PRODUCT FORMAT	SOURCE	ESTIMATED YEARLY PRODUCT VOLUME* GD 1	GD 2	GD 3	GD 4	TOTAL	USE OF DATA PRODUCT
Seismic Data	9 track (800 BPI) magnetic tape P- and S-wave phase data, epidentral parameters and amplitude data recorded by seismometers and strong motion accerometers.	CIT/SL(150 Southern Calif. seismic stations) NGSDC (worldwide)	35	13	85	-	133	Complementary data to space geodetic and geopotential data for the development and evaluation of tectonic models.
Gravity Data	Digital 800 BPI tape of Gravimeter Data	CIT/SL (Southern Calif.) NGSDC (worldwide)	-	13	-	12	25	Verification and calibration of gravity field models based upon gravity perturbations to satellite orbits
Stress/Strain Data	Mag Tape (800 BPI) of strainmeter and stressmeter..	CIT/SL (Southern Calif.), Geolab (Calif.), NGSDC (worldwide)	-	-	17	-	17	Verification of crustal stress and strain field estimates derived from models of mantle convection and measured motions along faults based upon space data.
Geomagnetic Data	Digital (800 BPI) tape of air and ground based magnetometer data.	NGDB (United States) NGSDC (worldwide)	-	13	-	12	25	Verification and calibration of satellite magnetometer measurements
Earthquake Event Summary	Earthquake summary bulletin prepared by SEDAS of the USGS Seismology Branch utilizing a worldwide network of ≈2000 tele-seismic sensors. Bulletins specify time, location and intensity of seismic activity.	NGSDC	7	-	17	-	24	Correlation with areas of stress concentration computed from satellite based gravity field data for model verification.

*Volume specified in number of individual products (Tapes, maps, reports....)

TABLE 12.1

USER REQUIREMENTS FOR AUXILIARY DATA PRODUCTS, GEODYNAMICS DISCIPLINE (CONT.)

TYPE OF DATA	DATA PRODUCT FORMET	SOURCE	ESTIMATED YEARLY PRODUCT VOLUME* GD 1	GD 2	GD 3	GD 4	TOTAL	USE OF DATA PRODUCT
Geodetic Data	Computer listing in the form of 800 BPI digital tape or hardcopy are available to non-NOAA users. Positional data is available for ≈215,000 horizontal control points a and ≈ 500,000 vertical control points across the U. S.	NGDB	7	-	17	-	24	Control points serve as reference locations for the deployment of mobile VLBI and laser ranging systems.
Geologic Maps	Geological maps of crustal structure and areas of volcanism.	NGSDC, NCIC, DMA	7	13	17	-	37	Verification of crustal structures and distributions of volcanism inferred from space data based geodynamic models.

*Volume specified in number of individual products (Tapes, amps, reports....)

TABLE 12.2

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: GEODYNAMICS

(OBSERVATIONS)

	R & D ACTIVITY			
	EARTH DYNAMICS	EARTH STRUCTURE	REGIONAL CRUSTAL DEFORMATION AND MODELING	GEOPOTENTIAL FIELDS
REQUIREMENTS	GD1	GD2	GD3	GD4
Horizontal Resolution (KM)				
Minimum	100	100	0.02	200
Maximum	300	300	500	500
Modal	-	200	200	200-500
Vertical Resolution (KM)				
Minimum	N.A.	N.A.	N.A.	N.A.
Maximum	N.A.	N.A.	N.A.	N.A.
Modal	N.A.	N.A.	N.A.	N.A.
Frequency				
Minimum	1 Year	1 Year	1 Year	1 Year
Maximum	1 Year	1 Year	4 Wks.	4 Wks.
Modal	1 Year	1 Year	1 Year	1 Year
Data Delivery				
Research Investigations	4 Wks.	3 Months	4 Wks.	4 Wks.
Technology Transfer	N.A.	N.A.	N.A.	N.A.

TABLE 12.2 (cont'd)

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: GEODYNAMICS

(SPECIAL SERVICES)

REQUIREMENTS	R & D ACTIVITY			
	GD1	GD2	GD3	GD4
Format Space Geodetic Data (VLBI and Laser Ranging Data) in a Computer Compatible Form	•	•	•	
Format Satellite Derived Gravity Field Data in a Computer Compatible Dorm	•		•	
Provide Interactive Central Storage and Retrieval System for Space Geodetic Data and Ancillary Data Including Catalog and Dictionary Services	•	•	•	
Provide Space Geodetic Data Within 3 to 6 Months after Collection	•	•		
Display Correlative Data in a Format Compatible with that used for Satellite Derived Gravity and Magnetic Field Data		•		
Provide the Capability for Investigators to perform Interactive Data Processing in a Data Service Computer via a Remote Terminal, Including Graphics Display Capability and Access to Standard Algorithms for Typical Processing		•		

TABLE 12.2 (cont'd)

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: GEODYNAMICS

(STANDARD ALGORITHMS)

	R & D ACTIVITY			
REQUIREMENTS	GD1	GD2	GD3	GD4
Time Series Analysis	•	•	•	
Data Inversions	•	•	•	
Spectral Analysis	•	•	•	
Gravity Field Models				•
Magnetic Field Models				•

that the choice of the link is driven by economic cost-effectiveness rather than by technical urgency. For example, a plausible ADS scenario may well incorporate a centralized accounting, scheduling and data traffic monitoring facility; which maintains track of expenditures on the part of the users, supplies them budgetary estimates, advises them of impending depletion of project funds. Further analysis might reveal that such centralized management function can be performed more cost-effectively through use of electronic data links than through other conventional alternatives; quite apart from considerations of speed.

As a gross sizing of the "electronic link" alternative, the corresponding transfer requirements are such as to engage the equivalent of approximately 3 data links of 1,200 bps capacity each, operating on a one shift, normal work week basis.

Because the driver is economics, not technology, system tradeoffs can exploit to the fullest special tariff structures and price breaks: e.g. discounts for off-time operation, quantity savings from use of bulk bandwidths, use of satellite links whenever transfer distance exceeds the cost breakpoint (currently of order 900 kilometers).

Analysis of Table 12.2 and 12.3 permits the inference that user services related to imagery manipulation---e.g. geocoding, superposition of formats, gridding---will not impose significant technological requirements upon ADS. This is because relatively low spatial resolutions are adequate to satisfy the users.

TABLE 12.3
DATA SERVICE REQUIREMENTS FOR THE GEODYNAMICS DISCIPLINE

		EARTH DYNAMICS	EARTH STRUCTURE	REGIONAL CRUSTAL DEFORMATION AND MODELING	GEOPOTENTIAL FIELDS
DATA LOCATION	Data Catalog	■	■	■	■
	Data Dictionary	■	■	■	■
	Computer Search	●	●	●	●
DATA EDITING	Quality Control	●	●	●	●
	Data Sorting	●	●	●	●
REFORMATTING	Form Conversion	●	●	●	●
	Code Conversion				
	Coordinate Conversion	■	■	■	■
	Scale Conversion			●	
ASSEMBLY	Data Segment Preparation				
	Data Set Preparation	●	●	●	●
DATA INTEGRATION	Single-Source Multi-temporal Data Registration	●		●	
	Single-Source Multi-temporal Data Merging				
	Multi-Source Uni-temporal Data Registration	●	●	●	
	Multi-Source Uni temporal Data Merging				
	Data Gridding	●	●	●	●
	Data Overlay				
	Image Mosaicing				
SPECIAL PROCESSING	Radiometric Correction				
	Geometric Correction				
	Other				
DATA MGM'T	Data Archiving	●	●	●	●
	Data Delivery	1 ■	1 ■	1 ■	1 ■
OTHER		2■	2■	2■	2■

■ High Value Data Service ● Desirable Data Service

Note 1: 1 Month with Remote Terminal Access

Note 2: Comprehensive Data Documentation

Users need to have available approximately 5 significant types of algorithms, Table 12.2. A potential evolutionary trend in the latter part of the 1980-1990 decade is the transition from user-peculiar development of these algorithms to their routine use--after the necessary confidence resulting from high "batting averages" will have been achieved.

Such an evolutionary development would open the ADS to the opportunity of providing a centralized algorithm processing function. Algorithms which reach fruition would be transferred to this function for conventional provessing: the researcher would retain the function of developing the newer generations of algorithms.

12.3 Implications of ADS on the Geodynamics Discipline

The analysis of user requirements for the Geodynamics Discipline results in the following data-related points:

- The major portion of the data produced by OSTA's Geodynamics Program is unique to the ADS concept, in that it uses ground-based VLBI and Laser Ranging instrumentation operated by geodynamics researchers. Time from data acquisition by the experimenter to delivery to the data users typically requires up to 9 months. The geology/geodynamics panel of the data system workshop indicates that this data turnaround time is excessive, and that it adversely impacts the pace of research efforts. The panel stated that a 30 day turnaround time is desirable for the efficient operations of most users.

- The panel suggests that consideration be given to establishing a special Geoscience Information Network as part of ADS. The network should be of the decentralized type and interconnect principal geodynamics investigators by remote "smart" terminals. It is expected that establishment of such a network would encourage the exchange and sharing of information and significantly improve data turnaround times, as well as optimize the costs of handling and processing geodynamics data.

- Data cost is not a major "driver" for improving data services in the Geodynamics Discipline area.

- Geodynamics data are located in a variety of public and private archives. There is no one single point of contact from which to determine what data is available and the proper mechanism for its acquisition.

  The most important function identified by users for an ADS is the inventorying of all the various sets of earth science space satellite and aircraft data collected by NASA and the preparation of an electronic catalog. Of primary importance, the catalog must contain comprehensive data descriptions and include at least geographic location, type, dates, collecting/holding agency, scale, and sensing system.

- Geodynamics data are available in a variety of formats which require coregistration. Much of this diversity in format is attributed to the current absence of any format standards in the geodynamic field. Proliferation of different formats unnecessarily increases overhead related to reformatting by both investigators and data systems.

  ADS could significantly impact this problem in two ways; 1) by limiting the proliferation of varying data formats to those necessitated by efficiency or by compatibility with existing systems, and 2) by providing reformatting services for existing data.

- Geodynamics research often involves the measurement of very minute differences of parameters over temporal and spatial baselines that are larger than the measurements sought by factors of 10^6 to 10^7. Researchers examining these minute relative changes must be capable of verifying that observed changes are due to changes in the earth and not due to variations of sensor types, calibration, data reduction or models employed to account for known factors (e.g., earth tides). Current data banks do not typically provide adequate documentation to permit cross-investigation comparisons and validations.

- A geodynamics data archive should be developed and maintained. It should include sufficient information concerning data collection and calibration procedures to ascertain any data's pedigree. The pedigree should include the instrument type(s), calibration information (value and time of last calibration), validation(s) performed, compression or reduction techniques used, and models of numerical techniques employed to derive that datum or the parent data from which that datum was derived.

  This information would not only aid present ongoing studies, but serve valuable historical and correlative purposes as new techniques and procedures come online.

In summary, the principal impact of an ADS upon the users of the Geodynamics Discipline would be enhancement of researcher performance and reduction of costs related to data acquisition and reformatting.

Key functions would promote increased efficiency. In approximate priority:

- Comprehensive data catalog with data pedigree information
- Establishment and maintenance of an interactive decentralized geoscience data network
- Standardization of geodynamics data formats
- Reformatting services
- Reduction of data turnaround time by a factor of 6 or better.

13.1 Description of Objectives and Content

The principal role of land use planning rests currently with local agencies -- States, Counties, Municipalities. Principal applications of land use information to support the formulation of regulations and ordnances aimed at optimal usage of the land, e.g., zoning, and as a basic tool for projecting the evolution of the land resource and the corresponding management policies.

The Federal Government's role in land management activities falls into three distinct areas: 1) land use planning on federally owned lands; 2) activities of the various federal agencies that impact land use; and 3) federal programs that attempt to provide guidelines to state and local land use planning.

Principal responsibility for administering 61% of all Federal lands resides with the Department of Interior's Bureau of Land Management. The remaining 39% is managed by USDA's Forest Service. Each of these agencies conduct a broad program of land resources monitoring and assessment activities.

OSTA's Land Use Discipline Program is structured to support and augment Federal, State, and local land resources analysis and management programs by fostering the incorporation of space acquired data. Due to the diversity and complex interrelationships between land use, land cover and land resources this is accomplished through a basic SR & T program designed to develop the capabilities to inventory, analyze, and assess the level of human use of land at various spatial scales and at the repetitive cycle required to meet the needs of diverse land resource planning, management, regulation and research personnel.

Land Use discipline activities are targeted to develop satellite multispectral and multitemporal classification techniques that can compensate for efforts associated with low resolution space data and also to accommodate space-acquired data with improved spatial resolution (15-30 m or less) as it becomes available.

OSTA's Land Use Discipline Program anticipates the effective demonstration of the research feasibility of employing change detection techniques which utilize remotely sensed data as an integral data source in the near future to include: image differencing, principal components differencing, and classification differencing.

Current OSTA Program

OSTA's efforts in Land Use fall into four categories of R&D Activities:

LU 1 Land Use/Cover Classification

The spectral, spatial and temporal characteristics of selected land resources targets in various geographical regions are examined with existing and newly acquired remotely sensed data and corresponding ground data sets. The selection of targets and target characteristics to be evaluated is based in part on the research needs evident from the recent user needs/design requirements studies, e.g., operational earth resources satellite (OERS) and integrated remote sensing system study (IRS3). Landsat-3 RBV digital data is processed when available and is analyzed for land cover information derived from the Landsat MSS data. A key goal is to evaluate and investigate the use of remotely sensed parameters for discriminating urban versus non-urban land cover in the urban fringe zone to aid the Census Bureau to periodically update or delineate urban expansion.

The significance is that land cover and land use information is central to all land resource applications. The relative rapidity of the dynamic changes in land use occuring in the coastal urban and suburban regions make them promising candidates for repetitive remote sensing assessment of land use and land cover. Typical of the important federal mandated programs supported by this effort, is the Bureau of Census' requirements for updated delineation of the standard metropolitan statistical area (SMSA's). Recent legislation and requirements of several federal and state funding programs has increased the need for more frequent updates of selected demographic variables. Remote sensing promises to be an effective tool for monitoring the 300 urbanized areas in the U.S. during the period 1980-1985.

LU 2 Remote Sensing Input to Geobased Information Systems

Automated data bases are being developed for selected study sites located in an expanding urban fringe area. Software is being written to automate the integration of Landsat data with the other resource data in the data base. The integrated data will be used to assist in the detection of urban expansion. Map products are produced to display the spatial extent of urban growth. Statistics which quantify urban expansion and the resultant agricultural land losses are derived.

Increasingly, the diverse data types required for comprehensive land resource investigations are being converted to digital formats and input to automated, geographically referenced data bases for efficient storage, retrieval, manipulation, analysis and display. Developing the ability to efficiently integrate Landsat data with other spatial land resource information will increase the availability and timeliness of information required for assessing the impact of urban expansion on critical agricultural lands. The use of these source data and derived information to develop a predictive urban land use change model can provide valuable input to policy decisions affecting agricultural land preservation.

LU 3 Land Use-Cover Change Detection

Improvements in the capability to detect land use/land cover change for land resource surveys are being investigated through the use of remotely sensed data, including image differencing, classification differencing, multitemporal classification, and principal component transformation.

The basic information interest of planning and management agencies is the change of a land use/land cover category, e.g. the rapid urban expansion into vacant or agricultural lands is important to agencies such as the Bureau of the Census, Department of Agriculture and planning agencies at the state and local government levels. Remotely sensed data when used multitemporally provide a timely, repetitive, standarized and synoptic data source for detecting land use change.

LU 4 Land Resources Modeling

Deterministic predictive land resource models are developed based upon theoretic economic and sociologic constraints using Landsat data to test various models of change. The applicability of satellite data to the verification of model prediction is evaluated. The use of statistical techniques to predict the future spatial extent of urban growth is investigated.

Satellite remote sensing offers significant potential for collecting several types of the generally "stable" input parameters for land capability models. In addition to "stable" physical parameters, inputs to suitability models often include dynamic land use parameters, for which satellite and aircraft remote sensing is especially well suited. Satellite remote sensing also offers the potential for providing the dynamic temporal element necessary for evaluating and extrapolating from present land resource trends. The ability to identify accurately predetermined land cover/land use changes in a spatial context adds greatly to the planning process. The ability to predict possible changes in system structure and assess the possible impact of varied decisions through the generation of numerous scenarios provides planners with an added and substantial capability.

Near Future OSTA Program

At the present time, OSTA is supporting several information systems research, pilot tests, and technology transfer projects. These include the Texas Natural Resource Information System (TNRIS) Application System Verification Test (ASVT) at JSC; California Integrated Resource Information System (CIRIS) ASVT at ARC; Census Application Pilot Test (APT) at GSFC; Navajo APT at ERL; and work on improving NASA large area Landsat mosaicking capability being conducted at JPL. These projects have transferred proven manual techniques for direct digitization of rectified classified Landsat data; examined research topics on accuracy of registration technique; and developed point to polygon and polygon to point conversion software for efficient manipulation of Landsat with other data. Accurate and efficient manipulation of classified Landsat data in digital form in an information system should effectively be demonstrated by 1983.

The U.S. Bureau of Census and NASA are presently conducting a Census Urbanized Area Applications Pilot Test (APT) project designed to evaluate the utility of Landsat digital data for providing rapid, cost-effective delineation of urbanized boundaries. Several approaches to data formatting and manipulation are being assessed including the potential applications of combining Landsat and ancillary data to enchance output products, provide area statistical summaries, and allow for spatial and statistical analysis within the context of an automatic geographic information system.

Future OSTA Program

By 1990, the OSTA's Land Resources Discipline Program is anticipated to have developed spaceborne remote sensing capabilities exhibiting a high level of radiometric and geometric fidelity in the visible, near infrared, and thermal portions of the electromagnetic spectrum so that these data can be supplied in a routine fashion to agencies with land resources management, inventory, regulation, and planning responsibilities. The applications of active microwave remote sensing techniques for land resource research will have been demonstrated from space, with a spaceborne active - microwave data system being established in a research mode by 1990. Key milestone of the Future Program are:

- Initiation of multi-area land use inventory demonstrations
- Operational demonstration of high accuracy (USGA, Anderson) satellite derived Level I and II land cover map products
- Operational demonstration of direct digital data input and efficient interaction with other digital data within a geobased information system
- Development of predictive land use models which possess a high level of versatility with regard to both inputs and geographical area
- Pilot tests to demonstrate the operational utility of OSTA developed predictive land use model

Figure 13.1 presents a graphic synopsis of OSTA's Land Use Discipline Program.

The first portion of the Figure reflects the space missions, current and projected, whose data products support the Program. The subsequent portion and continuation sheets reflects the Program's endeavors for each identified R&D Activity.

Each element is referenced to its pertinent source documents; their titles are listed at the Figure's end.

13.2 Relationships between Data Services and the Land Use Discipline

Figure 13.2 summarizes the requirements for data products expressed by the users.

FIGURE 13.1

LAND USE DISCIPLINE TIMELINE

OSTA MISSIONS

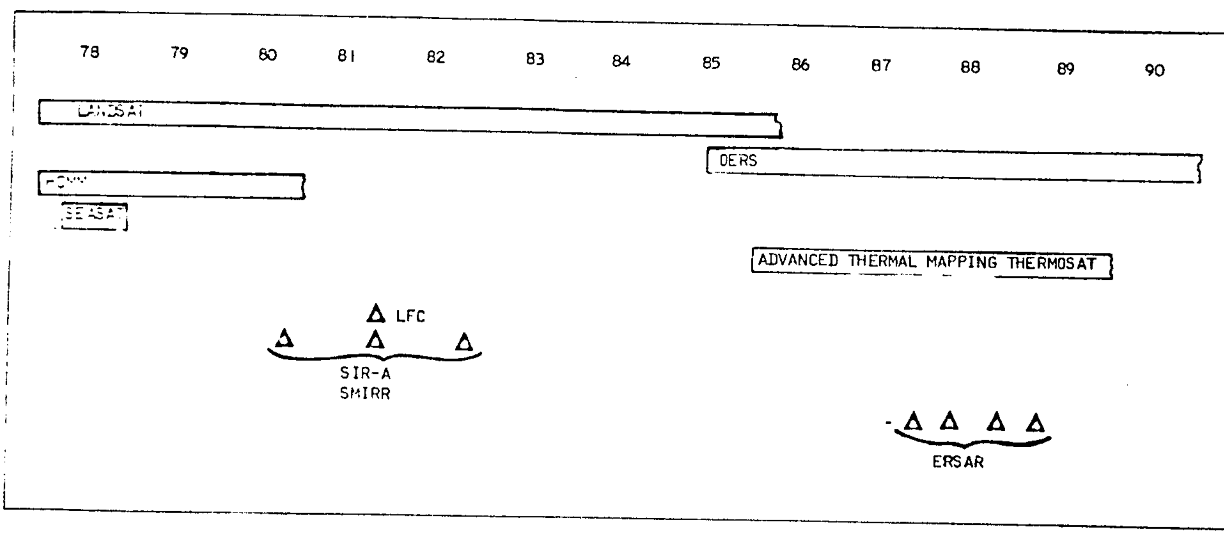


FIGURE 13.1 (cont'd)

LAND USE DISCIPLINE TIMELINE
R & D ACTIVITIES

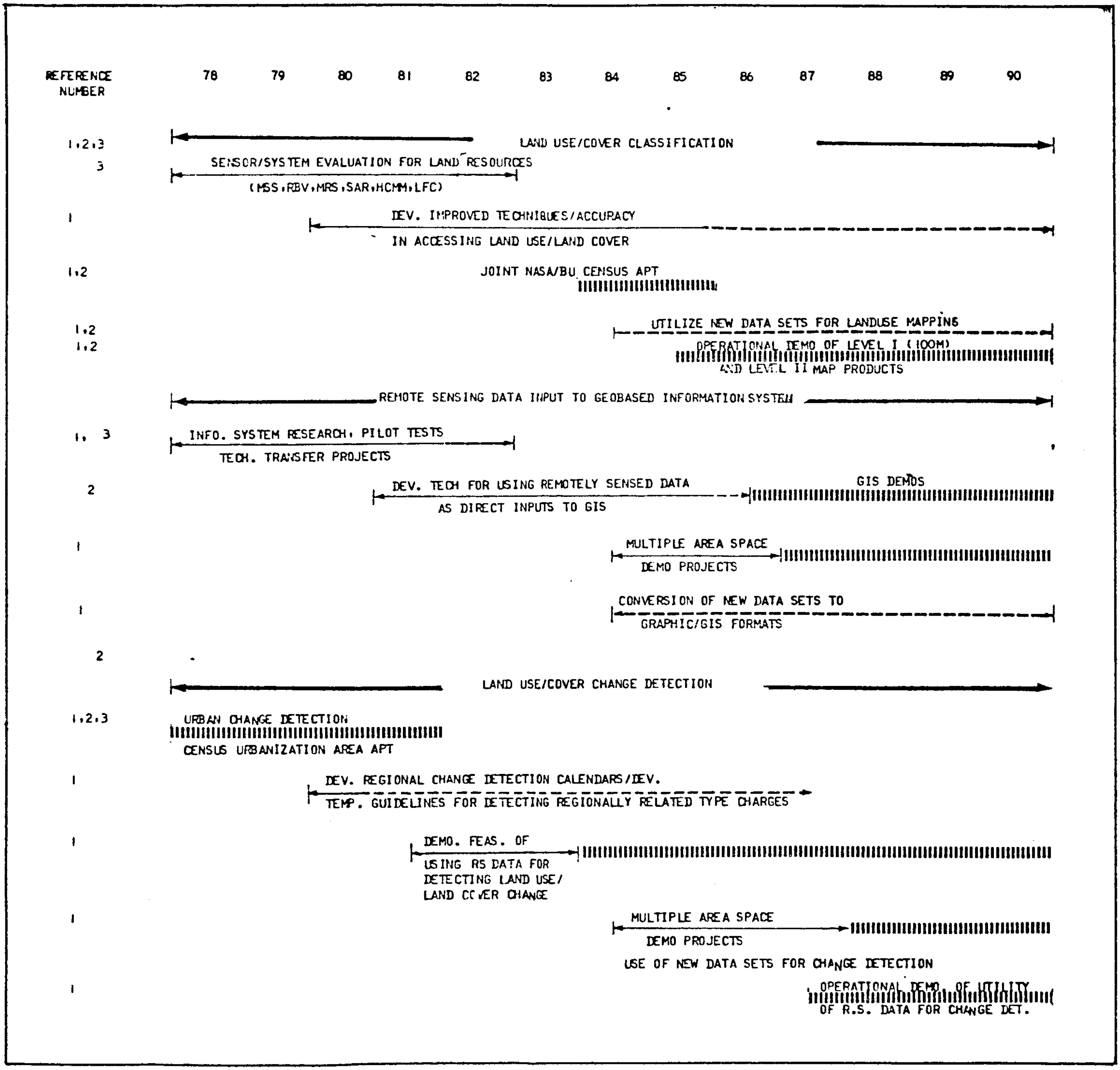
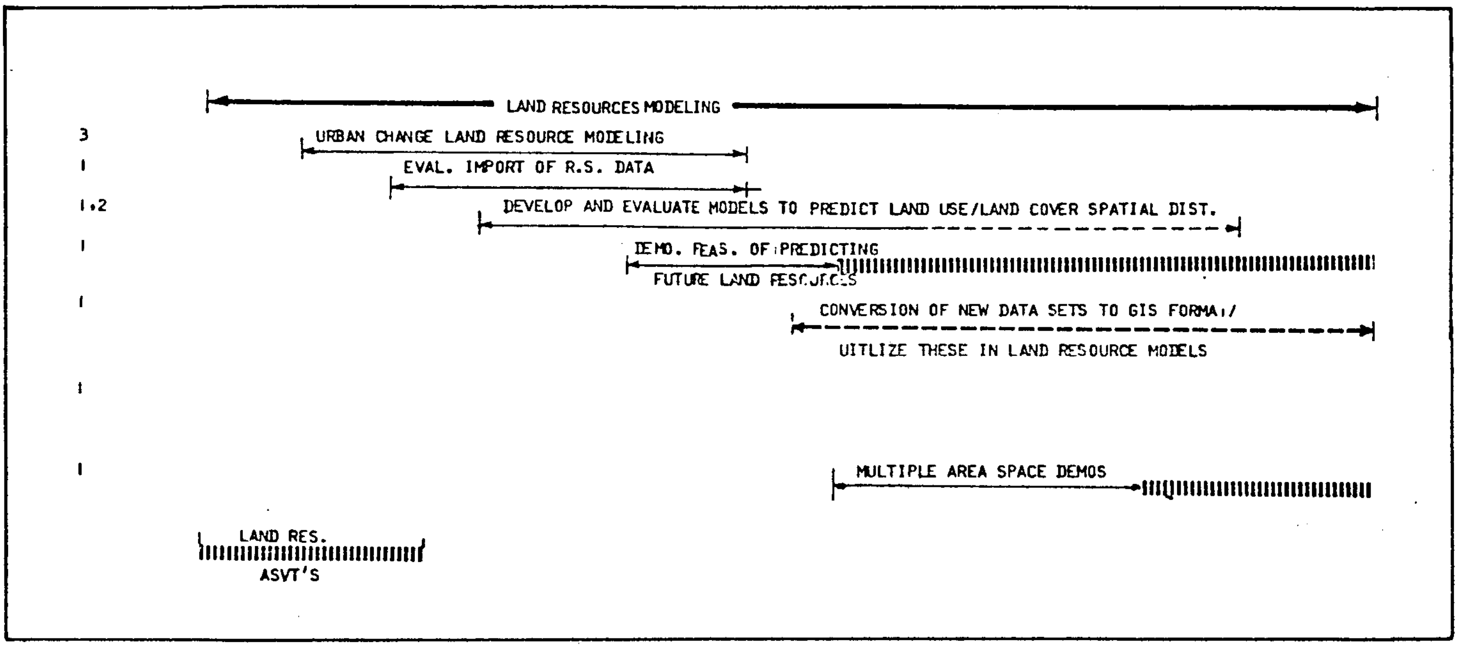


FIGURE 13.1

LAND USE DISCIPLINE TIMELINE (CONT'D)
R & D ACTIVITIES



REFERENCES:

1) A LAND RESOURCE RESEARCH PROGRAM FOR 1980-1990 (DRAFT) 1979
2) RESOURCE OBSERVATION 5-YEAR PLAN FY-81-85 PRESENTATION TO NASA PLANNING COUNCIL 1979
3) RTOPS 1979-80

LEGEND

1 Flight Mission
2 Program Emphasis
3 R&D Activity
4 Continuing Activity
5 Technology Transfer (Pilot/Application Tests Etc.)
6 Short Term Event
7 Initial Operational Capability
8 All Investigation Classes

FIGURE 13.2

USER REQUIREMENTS FOR SPACE DATA PRODUCTS, LAND USE DISCIPLINE

		LANDSAT		SEASAT	HCMM	LANDSAT D	OERS		SHUTTLE			THERMOSAT	
PARAMETERS		RBV	MSS	SAR	HCMR	TM	TM	MRS	SIR	LFC	ERSAR	AHCMR	
MULTISPECTRAL LAND COVER REFLECTANCE		●	●			●	●	●				●	
SOIL MOISTURE				●	●								
IRRIGATED AREA		●	●		●	●	●	●					
SNOW ICE/EXTENT		●	●	●	●	●	●	●	●	●	●	●	
SURFACE WATER EXTENT		●	●	●	●	●	●	●	●	●	●	●	
SURFACE TEXTURAL FEATURE		●	●	●	●	●	●	●	●	●	●	●	
DATA BANKS													
EROS		●	●			●	●	●	●	●	●		
JPL/SEASAT CDHF				●									
GSFC/IPD					●								
NOAA/NESS				●									
NSSDC					●				●		●	●	
PRODUCTS													**PRODUCT TOTALS**
1980	TAPES/YR.	338	508	90	41	-	-	-	-	-	-	-	977
	IMAGES/YR.	508	1294	8	-	-	-	-	-	-	-	-	1810
	OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-
	G BITS	12	18	3	1	-	-	-	-	-	-	-	34
1985	TAPES/YR.	-	-	-	-	155	1205	126	80	-	-	35	1610
	IMAGES/YR.	-	-	-	-	-	990	72	-	14	-	-	1076
	OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-
	G BITS	-	-	-	-	5	42	4	3	-	-	1	56
1990	TAPES/YR.	-	-	-	-	-	1271	161	-	-	71	29	1532
	IMAGES/YR.	-	-	-	-	-	990	72	-	3	-	-	1065
	OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-
	G BITS	-	-	-	-	-	45	6	-	-	2	1	54

Users are interested in obtaining parameters. These are intermediate information products derived from sensor measurements, elaborated via the application of appropriate algorithms. For example, soil moisture information derives from remotely sensed radiance data, elaborated in conjunction with surface emmissivity, atmospheric absorption, sensor calibration data, auxiliary data and models to relate surface humidity to subsurface moisture profile.

Apparent exceptions to the desire for parameters are the two requirements for "multispectral land cover reflectance" and "surface texture features". The reason is that the parameters needed in land use are so diverse -- e.g., cropland, feedlots, suburban, built-up -- and so variable among locales -- e.g., large and/or small farmsteads, low to high density suburban, forest, shrub, tundra -- that their specification for all classes and all locales is near to impossible; it would require knowledge of all user's desires -- federal, state, local, municipal, private -- and prediction of the evolution of these desires.

Land Use Discipline users thus prefer to receive good multispectral reflectance and textural data -- which form the core of remotely sensed data for this discipline -- and elaborate the appropriate algorithms case by case in response to the needs of each application.

NASA users in the Land Use Discipline are in the process of developing such algorithms. For this purpose, they wish to receive raw space data, augmented by the auxiliary data summarized in Table 13.1.

The volume of required space data shows a moderate increase through the 1980-1990 decade, from approximately 35 to 55 Gigabits/year. The volume required of auxiliary data, from Table 13.1, is approximately one half that of the space data.

From Figure 13.1, OSTA's program is devoted to both research and technology transfer efforts throughout the 1980-1990 decade. Table 13.2 shows in either case the corresponding acceptable time lapse of data delivery is of order one month.

Thus, ADS data transfer requirements can be satisfied by a service of data rate comparable to that of the U.S. mail.

The slow data delivery requirements do not necessarily connote that electronic linkages are not desirable. They simple indicate that the choice of the link is driven by economic cost-effectiveness rather than by technical urgency. For example, a plausible ADS scenario may well incorporate a centralized accounting, scheduling and data traffic monitoring facility; which maintains track of expenditures on the part of the users, supplies them budgetary estimates, advises them of impending depletion of project funds. Further analysis might reveal that such centralized management function can be performed more cost-effectively

TABLE 13.1

USER REQUIREMENTS FOR AUXILIARY DATA PRODUCTS, LAND USE DISCIPLINE

TYPE OF DATA	DATA PRODUCT FORMAT	SOURCE	ESTIMATED YEARLY PRODUCT VOLUME*					USE OF DATA PRODUCT
			LU 1	LU 2	LU 3	LU 4	TOTAL	
Topographic Data	Elevation Contour Maps	NCIC DMATC	14	4	6	20	44	Supplement satellite derived topographic data for evaluating limitations or constraints on the use of land. Parameters of elevation aspect and slop are important to radiometric correction of remotely sensed data.
	Topographic Maps 1:24,000 scale delineating roads, boundaries of drainage areas, political boundaries, rivers ...	NCIC DMATC	14	4	6	20	44	
	Digital (800 BPI) Earth Terrain Tapes specifying surface elevation for a national network of geodetic control points	NCIC	7	4	3	10	24	
Aerial Photography	Black and White Aerial photographs acquired by NASA, USDA/ASCS, USDA/SCS, US Forest Service, Bureau of Land Management, NOAA/National Ocean Survey and various other Federal agencies	NCIC EROS	70	20	30	100	220	Verification of land use/cover classifications based upon data from satellite borne remote sensors
Soils Data	Soil Maps showing soil type, aerial extent and zonal depth	NCIC USDA (CMC)	14	4	6	20	44	Verification of satellite determined soil characteristics

*Volume specified in number of individual products (Tapes, maps, reports,...)

TABLE 13.1

USER REQUIREMENTS FOR AUXILIARY DATA PRODUCTS, LAND USE DISCIPLINE (CONT.)

TYPE OF DATA	DATA PRODUCT FORMAT	SOURCE	ESTIMATED YEARLY PRODUCT VOLUME* LU 1	LU 2	LU 3	LU 4	TOTAL	USE OF DATA PRODUCT
Meteorologic Data	Digital (800 BPI) Tape of averaged monthly and annual precipitation, air temperature and air humidity at World Weather Watch synoptic data stations	EDIS (NCC)	-	4	-	20	24	Supplement satellite derived land cover data for evaluation of the applicability of land areas for various uses
Land Use Data	Land Use Maps delineating the aerial extent of various land use classes	NCIC DMATC USDA (CMC)	-	-	6	20	26	Provides basis for comparison with land use determined utilizing remote sensing techniques to evaluate land use change
Socio-Economic Data	Digital (800 BPI) Census Summary Tapes. Census data is referenced by census tracts and on a smaller scale by enumeration districts	U.S. Bureau of Census	-	4	-	20	24	Important supplementary data for input to land use change forecast models and for use by land use planners

Volume specified in number of individual products (Tapes, maps, reports....)

TABLE 13.2

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: LAND USE

(OBSERVATIONS)

	R & D ACTIVITY			
	LAND USE/COVER CLASSIFICATION	REMOTE SENSING INPUT TO GEOBASED INFORMATION SYSTEMS	LAND USE/COVER CHANGE DETECTION	LAND RESOURCES MODELING
REQUIREMENTS	LU 1	LU 2	LU 3	LU 4
Horizontal Resolution (KM)				
Minimum	0.03	0.03	0.03	0.03
Maximum	0.1	0.1	0.1	0.1
Modal	0.03-0.1	0.03-0.1	0.3-0.1	0.3-0.1
Vertical Resolution (KM)				
Minimum	N.A.	N.A.	N.A.	N.A.
Maximum	N.A.	N.A.	N.A.	N.A.
Modal	N.A.	N.A.	N.A.	N.A.
Frequency				
Minimum	6 Months	1 Year	1 Year	6 Months
Maximum	6 Months	2 Months	-	-
Modal	6 Months	2-12 Months	-	-
Data Delivery				
Research Investigations	4 Weeks	4 Weeks	4 Weeks	4 Weeks
Technology Transfer	4 Weeks	4 Weeks	4 Weeks	4 Weeks

TABLE 13.2 (cont'd)

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: LAND USE

(SPECIAL SERVICES)

REQUIREMENTS	R & D ACTIVITY LU 1	LU 2	LU 3	LU 4
Georeferenced Satellite Data Products	•		•	•
Multisensor Data Merging for Pattern Recognition	•		•	•
Multitemporal Data Merging for Improved Discrimination	•		•	•
Provide Auxiliary Data In a Computer Compatible Form		•		
Multisource Data Management System for Storing, Retrieving, Manipulating, Analyzing and Displaying Multisource Geobased Information Via Remote Terminal		•		

(STANDARD ALGORITHMS)

REQUIREMENTS	R & D ACTIVITY LU 1	LU 2	LU 3	LU 4
Multispectral Pattern Recognition Schemes	•		•	•
Land Use Change Models		•		•
Predictive Model for Urban Sprawl				•

through use of electronic data links than through other conventional alternatives; quite apart from considerations of speed.

As a gross sizing of the "electronic link" alternative, the corresponding transfer requirements are such as to engage the equivalent of approximately 6 data links of 1,200 bps capacity each, operating on a one shift, normal work week basis.

Because the driver is economics, not technology, system tradeoffs can exploit to the fullest special tariff structures and price breaks: e.g. discounts for off-time operation, quantity savings from use of bulk bandwidths, use of satellite links whenever transfer distance exceeds the cost breakpoint (currently of order 900 kilometers).

Analysis of Tables 13.2 and 13.3 permits the inference that user services related to imagery manipulation -- e.g. geocoding, superposition of formats, gridding -- will impose significant technological requirements upon ADS. This is because quite high spatial resolutions are needed to satisfy the users.

Users need to have available approximately 3 significant types of algorithms, Table 13.2. A potential evolutionary trend in the latter part of the 1980-1990 decade is the transition from user-peculiar development of these algorithms to their routine use -- after the necessary confidence resulting from high "batting averages" will have been achieved.

TABLE 13.3

DATA SERVICE REQUIREMENTS FOR THE LAND USE DISCIPLINE

		LAND USE/ COVER CLASSIFICATION	REMOTE SENSING DATA INPUT TO GEOBASED INFORMATION SYSTEMS	LAND USE/ COVER CHANGE DETECTION	LAND RESOURCES MODELING
DATA LOCATION	Data Catalog	■	■	■	■
	Data Dictionary	■	■	■	■
	Computer Search	●	●	●	●
DATA EDITING	Quality Control				
	Data Sorting	■	■	■	■
REFORMATTING	Form Conversion	●	●	●	●
	Code Conversion				
	Coordinate Conversion		■		
	Scale Conversion	■	■	■	■
ASSEMBLY	Data Segment Preparation	■	■	■	■
	Data Set Preparation	●	●	●	●
DATA INTEGRATION	Single-Source Multi-temporal Data Registration	●	●	■	●
	Single-Source Multi-temporal Data Merging	●	●	●	●
	Multi-Source Uni-temporal Data Registration	■	●	■	●
	Multi-Source Uni temporal Data Merging	●	■	●	■
	Data Gridding				
	Data Overlay	●	●	■	●
	Image Mosaicing	●	●	●	●
SPECIAL PROCESSING	Radiometric Correction	■	■	■	■
	Geometric Correction	■	■	■	■
	Other				
DATA MGM'T	Data Archiving				
	Data Delivery				
OTHER					

■ High Value Data Service ● Desirable Data Service

Such an evolutionary development would open the ADS to the opportunity of providing a centralized algorithm processing function. Algorithms which reach fruition would be transferred to this function for conventional processing: the researcher would retain the function of developing the newer generations of algorithms.

13.3 Implications of ADS on the Land Use Discipline

The analysis of user requirements for the Land Use Discipline results in the following data-related findings:

- Current delivery of space data are of order two to four weeks. They are adequate to support all OSTA land use investigators.

- Space product costs are not a significant concern of OSTA land use investigators.

- A key conclusion of the Data Systems Workshop's Land Resources Panel was that land use investigators need to gather data with greater efficiency. Currently, investigators gather these from a wide variety of basically unarchived and unannotated sources. Dealing with a variety of data banks is time consuming: users universally express the need for a centralized facility from which they can locate and acquire the bulk of the needed data. An important aspect of such a service is provision of a standard annotated catalog and dictionary: indicating what data are available, their characteristics, and location. Another major function of the service would be provision of unified standard procedures for ordering and acquiring data, thus eliminating the need for users to familiarize themselves with a multitude of data ordering procedures.

- Considerable cost savings could result from providing a quick look service to reduce the ordering of nonoptimal data sets.

This service should include space image products and key auxiliary data products, e.g. aircraft imagery.

- Currently each investigator develops and applies his own algorithms to perform a variety of processing functions e.g. radiometric and geometric correction, coordinate transformation. These functions are required by all land use investigators.

  Their standardization would be a universally accepted benefit to OSTA users and to the land use community at large.

- Land use researchers indicate that land cover classification accuracy increases when integrated multitemporal and multisensor data is used (e.g. Landsat MSS and Seasat SAR). *Data merging and integration is probably the most time consuming data handling element currently experienced by investigators outside of data analysis.* The data/image transformation services required entail elements of both data set preparation and reformatting. Potential processing operations required to convert disparate data to a common form and scale, suitable for input to classification schemes include:

  a) multi-sensor, unitemporal and multitemporal registration, entailing the congruencing and rescaling of data of different scale and aspect angles;

  b) geographic referencing;

  c) coordinate transformations, for example space oblique mercator to universal transverse mercator;

  d) data overlay and gridding;

  e) mosaicing, in which adjacent swaths of space or airborne imaging sensors are equalized radiometrically, congruenced, rescaled, laterally registered, and organized in a wide-area digital data file.

- The availability of different image classification schemes from a centralized facility would enhance the performance of land cover, land use and land use projection procedures. The various classification algorithms and procedures should be carefully annotated as to input requirements, utility and be provided with appropriate caveats as to applicability, time to process and expected performance accuracies. An interactive user training capability would probably have to be provided. The facility would have to maintain continuous updates on classification and algorithms and process online.

- The maintenance of an archive of OSTA intermediate and final processed land use products is a significant service in support of the Land Use Discipline. Products within this archive should be appropriately annotated for retrieval and cross-referenced by geographic area, region and date. This service is directly related to land use change detection investigation and provides ready access to previous land use classifications. The cost effectiveness of this archive of space-based land use products would prove to be invaluable to both internal researchers as well as the external user community. *The cross-discipline utility of this archive of land cover and land use products could prove to be a major benefit of an improved data service.*

In summary, the principal impact of an ADS upon the users of the Land Use Discipline would be economic, i.e. a significant reduction in the time and cost expenditures currently required by the researcher to acquire the integrated data sets they require, and enhanced researcher performance, i.e. standardization of data access and handling elements common to all land use investigators.

Five key functions would promote increased efficiency. In approximate priority:

- Comprehensive data catalog of satellite remotely sensed and auxiliary data
- Establishment of a centralized facility for the order and acquisition of auxiliary data
- Data merging and integration services
- Standardization of radiometric correction, geometric correction, coordinate transformation and image classification schemes
- Establishment of an archive for OSTA developed information products to support multiple investigations and to provide data feedback and as an historical data base for the general land use research community.

14.1 Description of Objectives and Content

The U.S. Geologic Survey is the Federal agency responsible for the collection, assessment and distribution of data and information pertaining to Non-Renewable Resources, e.g. fuels and minerals. These USGS information services are important to exploration, development and exploitation of these resources.

OSTA's Non-Renewable Resources Discipline Program supports the data collection and assessment activities of the USGS and other users of non-renewable resources information with a program directed toward the development of space technology and the conduct of related research to increase the effectiveness, the exploration, development and management of non-renewable resources on a global scale.

A committee drawn from the geologic user community, known as the Geosat Committee, concluded in a recent workshop report (Henderson and Swann, 1976), that the capability for low-cost, repetitive multispectral surveillance is of great potential value for developing resource properties; and for increasing production, once valuable minerals or oil have been discovered. A National Academy of Sciences (NAS) Panel on Extractable Resources recommended the development and test of sensors to cover the full spectrum of anticipated non-renewable resource indicators, and the provision of continuous synoptic imagery plus the option of high resolution imagery of selected targets.

The objectives of OSTA's Non-Renewable Resources Discipline Program are to:

- increase knowledge and understanding of regional subsurface structure and composition to facilitate the assessment of potentially valuable non-renewable resources lying therein;
- develop remote sensing techniques to aid local non-renewable resource exploration;
- develop methods and techniques to assist increasing the production and yield of valuable minerals and fuels after their discovery

Current OSTA Program

OSTA's efforts comprising the Non-Renewable Resources Discipline Program fall into five categories of R&D activities:

NR 1 Lithologic Assessment

Research in the use of spectral imagery from satellites to distinguish exposed rock types. These objectives are to: 1) determine and demonstrate the usefulness of IR and thermal IR spectral properties of surface materials for discriminating rock types; 2) determine in-situ the spectral signature of a variety of rocks; 3) determine the improvement in rock discrimination from combining in situ with spectral reflectance data; 4) determine usefulness of multispectral thermal IR for rock type discrimination based on the reststrahlen effect; 5) determine accuracy and utility of thermal inertia calculations under a variety of conditions; 6) evaluate capability to discriminate and identify rock types using advanced narrow band IR imaging systems; 7) evaluate the potential and capability of imaging radar sensors for geologic mapping; 8) assess the synergism of combining multispectral multipolarization radar data with other types of remote sensing data obtained in different regions of the electromagnetic spectrum (i.e., IR, visible, thermal IR).

The type of exposed rock can be a significant indirect indicator of underlying mineral deposits. Mapping of lineaments and lithologies is used for regional tectonic, stratigraphic and sedimentologic assessments preceding prospecting for mineral and pertroleum deposits.

NR 2 Geobotanic Mineral Exploration

Investigation of multiple wavebands and sensor types for evaluating geobotanical anomalies and for identifying specific rock lithologies to establish where in the electromagnetic spectrum changes in plant biochemistry and physiology induced by geologic factors can be detected.

Since developed areas have already been explored more thoroughly than remoter regions, and because desert regions display detectable outcrops, it is likely that most of the world's remaining mineral resources are hidden beneath vegetation. The vegetation's type, state of development and health can be an indicator of underlying mineral deposits

NR 3 Geophysics/Resources Emplacement Evaluation

Development of techniques to utilize Landsat, Aeromagnetics, gravity and auxiliary geological data in the preparation of "probable value maps", to develop more efficient reconnaissance techniques for the high risk early phases of mineral exploration programs.

The increasing scarcity of mineral and energy resources in the United States and the world necessitates the development of ever more efficient exploration techniques. Key to these is improving the "batting average" of the reconnaissance programs.

NR 4 Geologic Structure Assessment

Development and testing of procedures for investigating major geologic features by multivariate statistical analyses of multiple data (20 or more).

Traditional geological investigations using remotely sensed data have generally been restrictive because they have utilized only one or two data sets, primarily satellite multispectral data. Best exploitation of orbital multispectral data is expected to result from its combination with multiple other data.

NR 5 Engineering Geology

Development of techniques for merging remotely sensed data with in-situ measurements to assess characteristics of geotechnical structures important to large scale engineering applications.

The cost of obtaining geotechnical information by conventional means is very high. Bid costs for construction are higher because of incomplete knowledge on the part of construction companies. Improved information will lead to lower product costs.

Near Future Program

The major thrust of the near term Non-Renewable Resources Discipline Program will aim at lithologic assessment. It will focus on: 1) initiation of geologic fluorescence studies; and 2) initiation of studies of chemical weathering of rocks in arid regions.

On going projects in geobotanical mineral exploration will be strengthened through investigations into the fundamental relationships of geobotany.

A Stereosat study is planned to validate user requirements, investigate technology options, and synthesize system definitions and cost. A study is planned to determine how the SIR-A radar should transition to SIR-B activities and to provide general support for space microwave activities.

Future Program

OSTA's Non-Renewable Resources Discipline Program for 1985 and 1990 focuses along three areas of emphasis:

- Regional Assessment - development of methods for using satellite magnetic, gravity and imaging data, together with appropiate ground observations, to construct geological/geophysical models of subsurface structure and composition useful for the assessment of potentially valuable energy and mineral resources and regional scale.

- Local Explorations - development of remote sensing techniques to locate specific areas in which surface exploration for energy and mineral resources should be directed.
- Development of Energy and Mineral Resource Potential - development of remote sensing techniques and instrumentation for use in the location and development of mineral and oil resource properties and in the assessment of environmental impact before, during and after extractive operations.

Figure 14.1 presents a graphic synopsis of OSTA's Non-Renewable Resources Discipline Program.

The first portion of the Figure reflects the space missions, current and projected, whose data products support the Program. The subsequent portion and continuation sheets reflects the Program's endeavors for each identified R&D Activity

Each element is referenced to its pertinent source documents; their titles are listed at the Figure's end.

14.2 Relationships between Data Services and Non-Renewable Resources Disciplines

Figure 14.2 summarizes the requirements for data products expressed by the users.

Users are interested in obtaining parameters. These are intermediate information products derived from sensor measurements, elaborated via the application of appropriate algorithms. For example, surface temperature

FIGURE 14.1

NON-RENEWABLE RESOURCES DISCIPLINE TIMELINE

OSTA MISSIONS

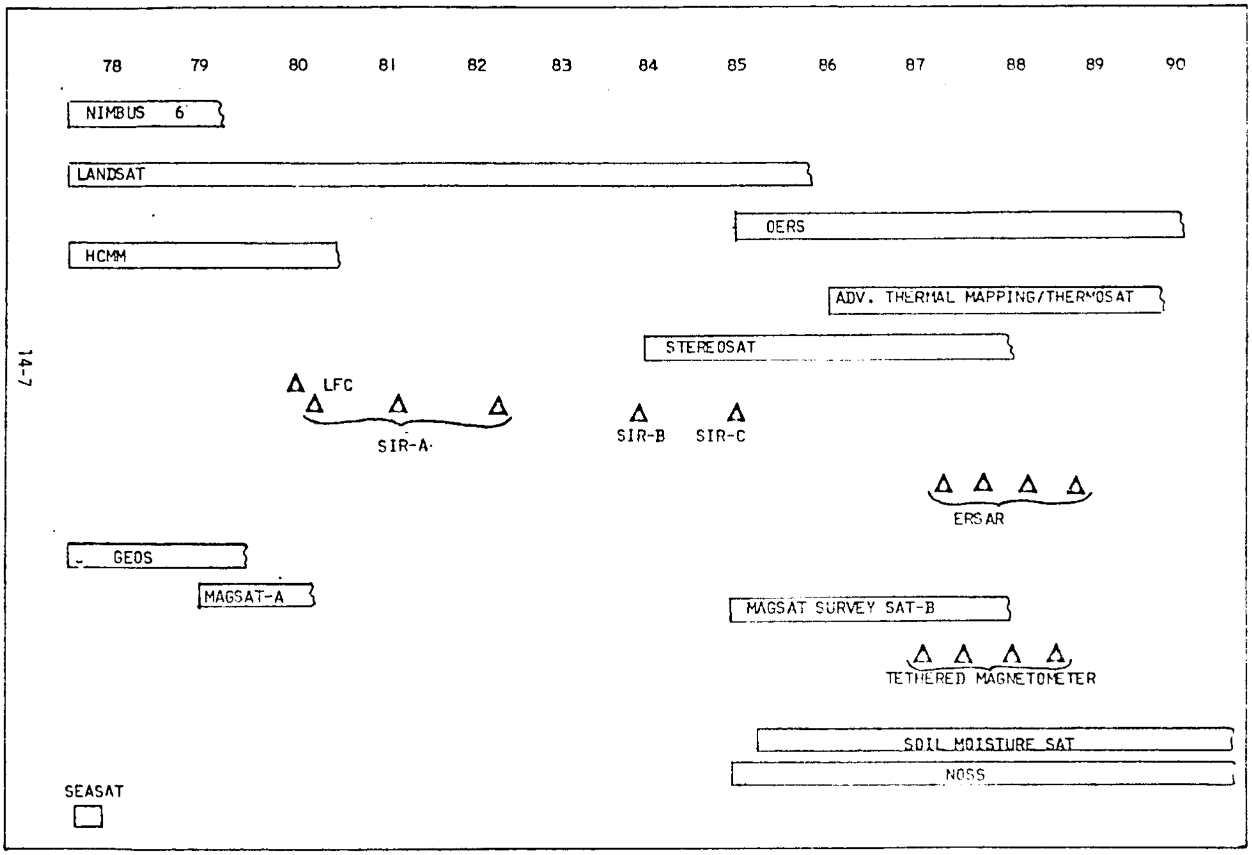


FIGURE 14.1

NON-RENEWABLE RESOURCES DISCIPLINE TIMELINE R & D ACTIVITIES

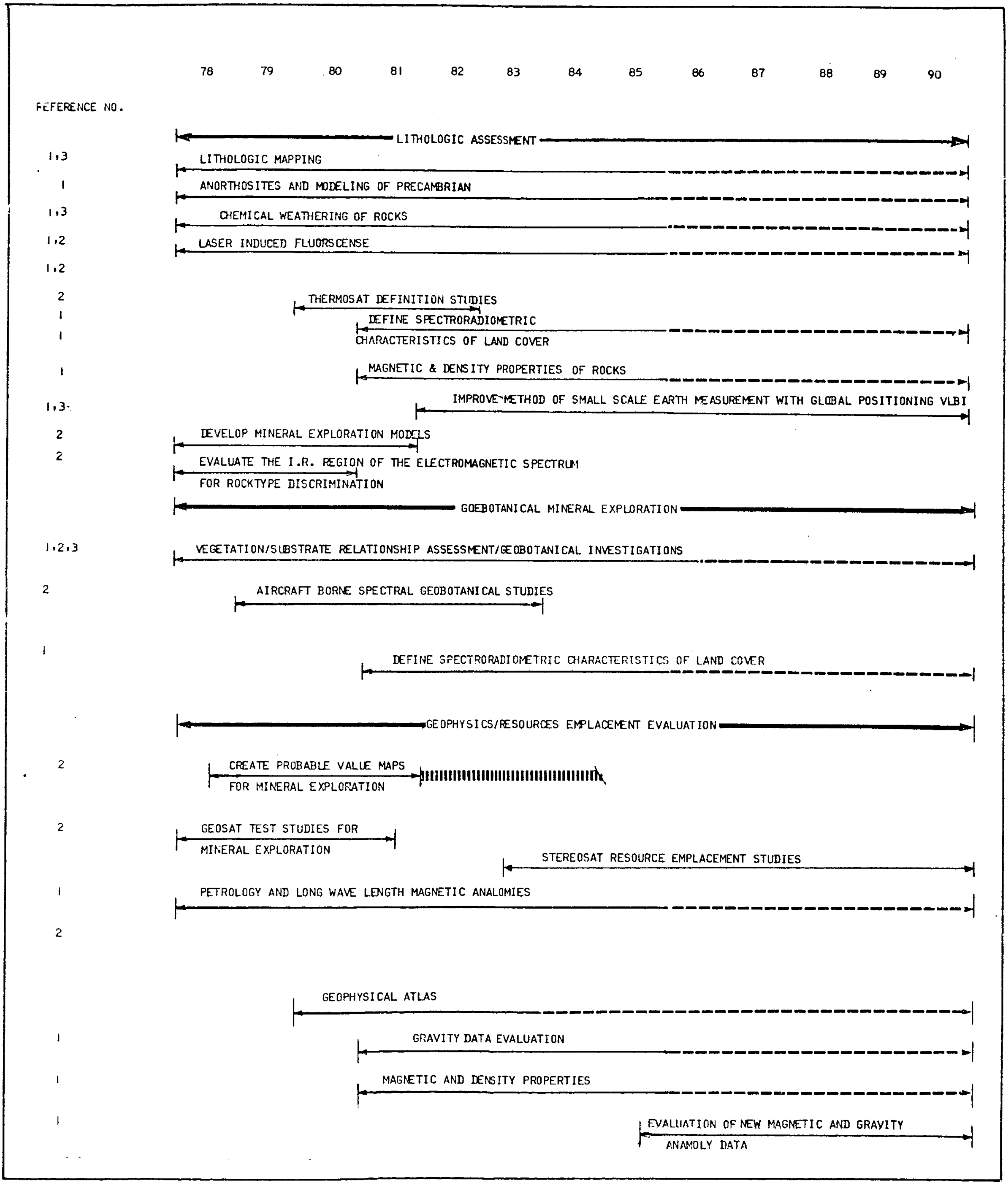
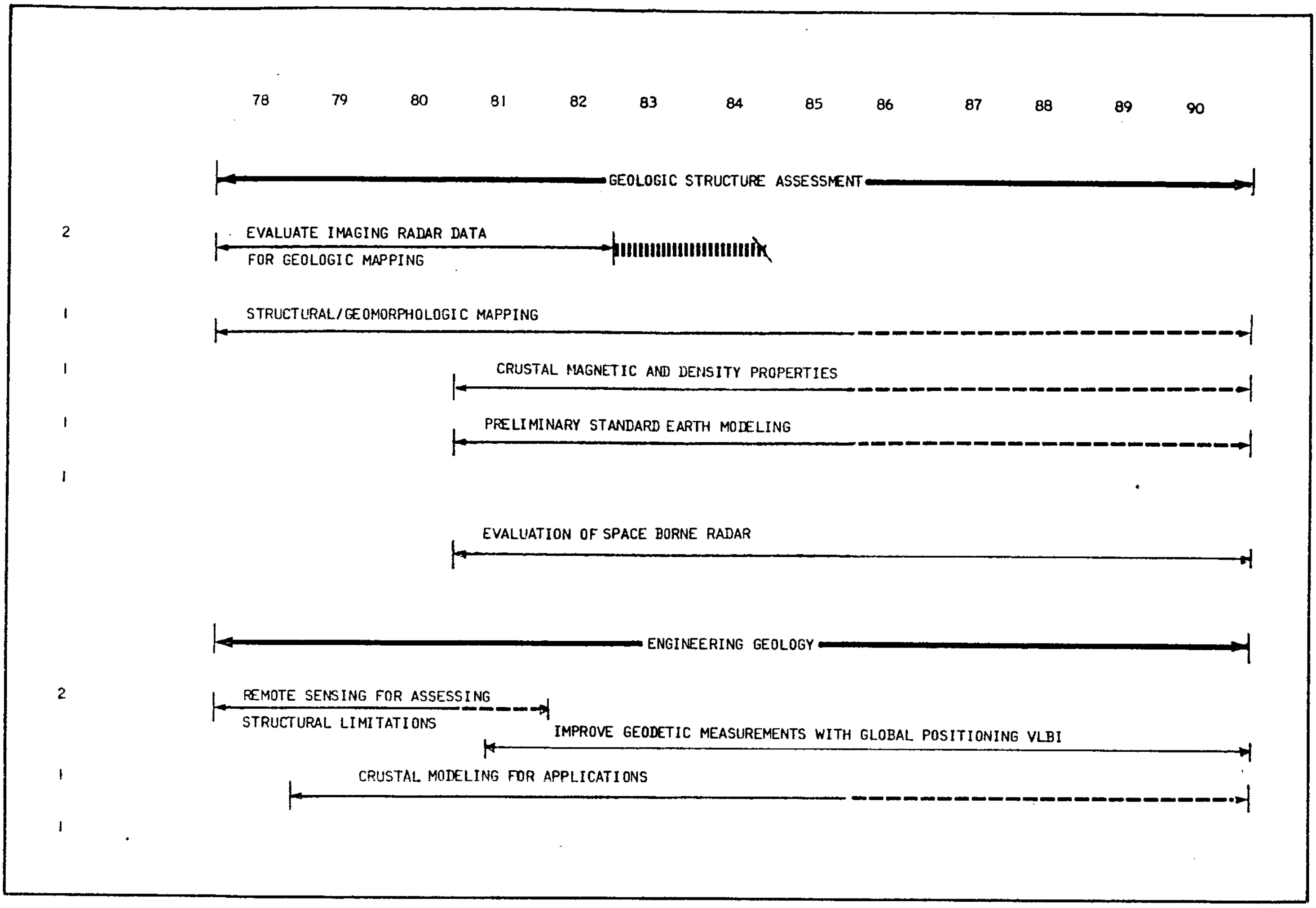


FIGURE 14.1

NON—RENEWABLE RESOURCES DISCIPLINE TIMELINE
R & D ACTIVITIES



REFERENCES:
(1) RESOURCES OBSERVATIONS 5 YEAR PLAN
(2) RTOPS 1980
(3) NON-RENEWABLE RESOURCES PROGRAM PLAN JUNE 1978

LEGEND

1 Flight Mission
2 Program Emphasis
3 R&D Activity
4 Continuing Activity
5 Technology Transfer (Pilot/Application Tests Etc.)
6 Short Term Event
7 Initial Operational Capability
8 All Investigation Classes

FIGURE 14.2

USER REQUIREMENTS FOR SPACE DATA PRODUCTS, NON-RENEWABLE RESOURCES DISCIPLINE

		SAT. TO SATELLITE TRACKING	LANDSAT		NIMBUS 6	SEASAT A		HCMM	GEOS	MAGSAT	POGO	LANDSAT D		THERM	SHUTTLE	STEREOSAT	NOSS		SOIL MOISTURE SAT		MAGSAT	OERS		SHUTTLE	
PARAMETERS			MSS	RBV	SMMR	SAR	ALT	HCMR	ALT	MAGNETOMETER	MAGNETOMETER	MRS	TM	AHCMR	SIR	STEREO TELESCOPE	ALT	LAMMR	MPMR	AMS	MAGNETOMETER	TM	MRS	ERSAR	
MULTISPECTRAL REFLECTANCE			●	●								●	●									●	●		
CANOPY TEMP.					●			●						●				●	●						
MAGNETIC FIELD STRENGTH										●	●										●				
GRAVITATIONAL FIELD STRENGTH		●					●		●								●								
SURFACE ELEVATION							●		●								●								
SURFACE TEMPERATURE					●			●						●				●	●						
LINEAR SURFACE FEATURES			●	●		●		●				●	●		●	●						●	●	●	
SOIL TEMP.					●			●						●				●	●						
SOIL MOISTURE					●	●		●						●	●			●		●				●	
DATA BANKS																									
EROS			●									●	●		●	●						●	●	●	
NOAA/NESS						●	●																		
JPL/SEASAT CDHF						●	●																		
GSFC/IPD								●		●				●						●					
NSSDC		●						●	●	●	●			●	●				●	●				●	
NOSS/PPF																	●	●							
PRODUCTS																									**PRODUCT TOTALS**
1980	TAPES/YR.	60	660	80	2	36	30	60	54	66	6	-	-	-	-	-	-	-	-	-	-	-	-	-	1054
	IMAGES/YR.	-	144	4	-	36	-	103	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	292
	OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	G BITS/YR.	2	23	3	1	1	1	2	2	2	.2	-	-	-	-	-	-	-	-	-	-	-	-	-	3.7
1985	TAPES/YR.	72	-	-	-	-	-	-	-	-	-	80	346	29	-	-	101	3	5	5	86	446	-	-	1173
	IMAGES/YR.	-	-	-	-	-	-	-	-	-	-	4	172	172	86	80	-	-	-	-	-	-	-	-	514
	OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	G BITS/YR.	2.5	-	-	-	-	-	-	-	-	-	3	12	1	-	-	3.5	0.1	0.2	0.2	3	16	-	-	41
1990	TAPES/YR.	86	-	-	-	-	-	-	-	-	-	-	-	35	-	-	121	3	6	6	103	950	20	-	1330
	IMAGES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	206	-	96	-	-	-	-	-	206	4	103	615
	OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	G BITS/YR.	3	-	-	-	-	-	-	-	-	-	-	-	1.2	-	-	4.2	0.1	0.2	0.2	3.6	33	0.7	-	47

information derives from remotely sensed radiance data elaborated in conjunction with surface emissivity, atmospheric absorption, sensor calibration data.

NASA users in the Non-Renewable Resources Discipline are in the process of developing such algorithms. For this purpose, they wish to receive raw space data, augmented by the auxiliary data summarized in Table 14.1.

The volume of required space data shows a modest increase through the 1980-1990 decade, from approximately 35 to 45 Gigabits/year. The volume required of auxiliary data, from Table 14.1 is approximately one tenth that of the space data.

From Figure 14.1, OSTA's program is devoted primarily to research efforts, with some technology, transfer activities throughout the 1980-1990 decade. Table 14..2 shows that the acceptable time lapse of data delivery is of order four weeks for both research and technology transfer efforts.

ADS data transfer requirements can be satisfied by a service of data rate comparable to that of the U.S. mail.

The slow data delivery requirements of the early time frame do not necessarily connote that electronic linkages are not desirable. They simply indicate that the choice of the link is driven by economic cost-effectiveness rather than by technical urgency. For example, a plausible ADS scenario may well incorporate a centralized accounting,

TABLE 14.1

USER REQUIREMENTS FOR AUXILIARY DATA PRODUCTS, NON-RENEWABLE RESOURCES DISCIPLINE

TYPE OF DATA	DATA PRODUCT FORMAT	SOURCE	ESTIMATED YEARLY PRODUCT VOLUME*						USE OF DATA PRODUCT
			NR 1	NR 2	NR 3	NR 4	NR 5	TOTAL	
Geological Maps	Geological Maps of crustal structure, areas of volcanism, mineral deposit locations, etc.	NGSDC, NCIC DMATC	12	4	5	4	1	26	Verification of satellite based techniques for location of non-renewable resource emplacements.
Lithologic Data	Digital (800 BPI) Tapes of rock description, location and chemical composition for ≃ 300,000 rock samples analyzed by USGS.	USGS(RASS)	12	-	-	4	-	16	Verification of satellite (HCMR, Landsat...) lithologic evaluations
Resource Deposit Data	Digital (800 BPI) Tape of metalic and non-metalic mineral resource deposit descriptions, locations and associated geology and minerology in formation for ≃ 50,000 deposits	USGS(CRIB)	-	4	5	4	-	13	Provides a basis for the evaluation of remote sensing techniques for mineral exploration
Seismic Data	9 track (800 BPI) mag tapes of P- and S-wave phase data, epicentral parameters and amplitude data recorded by seismometers and strong motion accelerometers	NGSDC	-	-	-	4	-	4	Complementary data for correlation with satellite data for the evaluation of geologic structure

*Volume specified in number of individual products (Tapes, maps, reports...)

TABLE 14.1

USER REQUIREMENTS FOR AUXILIARY DATA PRODUCTS, NON-RENEWABLE RESOURCES DISCIPLINE (CONT.)

TYPE OF DATA	DATA PRODUCT FORMAT	SOURCE	ESTIMATED YEARLY PRODUCT VOLUME*						USE OF DATA PRODUCT
			NR 1	NR 2	NR 3	NR 4	NR 5	TOTAL	
Soils Data	Soils maps illustrating soil type, aerial extent and zonal soil depth	USDA (CMC)	12	4	-	4	1	21	Verification/calibration of satellite derived soil property measurements.
Topographic Data	Elevation contour maps	NCIC, DMATC	12	4	5	4	1	26	Verification/calibration of satellite derived elevation data
	Digital (800 BPI) Earth Terrain Maps	NCIC	6	2	2	2	1	13	
Geomagnetic Data	Digital (800 BPI) Types of air and ground based mageta-meter data	NGDB (U.S.) NGSDC (World-wide)	- -	- -	5	4	-	9	Verification and calibration of satel-lite magnetometer measurements
Gravity Data	Digital (800 BPI) Tapes of gravimeter data	NGSDC	-	-	5	4	-	9	Verification and suplimentation of satellite derived gravity field data for evaluating geologic structure
Botanical Data	Vegetation Maps	ASCS USDA (CMC)	-	4	-	-	-	4	Verification/calibration of satellite based geobotanic resource exploration algorithms
Ground Water Data	Digital(800 BPI) Tapes of Geochemical data on ground-water (hardness, sodium-adsorption-ratio, and chemical constituents/ solutes)	WATSTORE	-	-	5	4	-	9	Complementary data for correlation with remote sensing data to assess resource exploration potential of selected areas.

*Volume specified in number of individual products (Tapes, maps reports....)

TABLE 14.2

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS NON-RENEWABLE RESOURCES

(OBSERVATIONS)

	R & D ACTIVITY				
	LITHOLOGIC ASSESSMENT	GEOBOTANICAL MINERAL EXPLORATION	GEOPHYSICS/RESOURCES EMPLACEMENT EVALUATION	GEOLOGICAL STRUCTURE EVALUATION	ENGINEERING GEOLOGY
Horizontal Resolution (KM)					
Minimum	0.01	0.01	0.1	0.1	0.02
Maximum	0.1	0.1	10	100	0.1
Modal	0.01-0.1	0.01-0.1	-	0.1	0.02-0.1
Vertical Resolution (KM)					
Minimum	N.A.	N.A.	N.A.	N.A.	N.A.
Maximum	N.A.	N.A.	N.A.	N.A.	N.A.
Modal	N.A.	N.A.	N.A.	N.A.	N.A.
Frequency					
Minimum	6 Months	4 Months	1 Year	1 Year	1 Year
Maximum	6 Months	4 Months	4 Months	4 Months	4 Months
Modal	6 Months	4 Months	1 Year	1 Year	4-12 Months
Data Delivery					
Research Investigations	4 Weeks	4 Weeks	4 Weeks	4 Weeks	4 Weeks
Technology Transfer	4 Weeks	4 Weeks	4 Weeks	4 Weeks	4 Weeks

TABLE 14.2 (Cont'd)

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: NON-RENEWABLE RESOURCES

(SPECIAL SERVICES)

	R & D ACTIVITY				
REQUIREMENTS	NR 1	NR 2	NR 3	NR 4	NR 5
Provide Map Overlays	•				
Provide Geometric and Radiometric Corrections to Remotely Sensed Data	•				
Format Data from the Laser Fluoromatic Linear Array Pushbroom Radiometer, TM Simulator and Various hand held radiometers for use of the GSFC/GIS		•			
Reformat Data to Accomodate the GISS Fraunhoffer Line Discriminator	•				
Modify existing software to within GSFC GIS to accept Geobotanical Information Inputs and Real Valued Data	•				
Provide Multisource Geobotanical Data Base to Support Future Research Efforts		•			
Arrange Landsat Geophysical and Geological Data in a Grid Based Upon Landsat Pixels			•		
Reformat and Regrid Existing Data Sets to Conform to Standard Grid Sizes			•	•	
Devlop Software for 3-D Spacial Modeling, Including Gravity and magnetic data			•		
Compile & Digitize Lineament Data Sets for Correlation with Remotely Sensed Data			•	•	
Register, Format and Grid all Data Types in the Data Management System				•	
Develop Multisource Data Sets for Comparison with Remotely Sensed Data				•	
Format Data to Fit the JPL IBIS Data Base					•
Provide Integration of Data Into a Comprehensive Geocoded Data Base Specifically Addressing Engineering Geology					•

TABLE 14.2 (cont'd)

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: NON RENEWABLE RESOURCES

(STANDARD ALGORITHMS)

REQUIREMENTS	R & D ACTIVITY				
	NR1	NR2	NR3	NR4	NR5
Geometric Corrections to Match Map Formats	•				
Photometric Corrections to Yield Accurate Relative Intensities	•				
Ratio and Difference to Identify and Enhance Variations in the Different Sensor Channels (i.e. Frequency and Polarization)	•				
Algorithm Development needed to Predict Missing Observations and Interpolation Values		•			
Textural Analysis and Multivariate Analysis Procedures for Major Geologic Features			•	•	
Delineation of Frozen v.s. Unfrozen Soil					•
Assessment of Soil Composition					•
Soil Moisture Profiles					•

scheduling and data traffic monitoring facility; which maintains track of expenditures on the part of the users, supplies them budgetary estimates, advises them of impending depletion of project funds. Further analysis might reveal that such centralized management function can be performed more cost-effectively through use of electronic data links than through other conventional alternatives; quite apart from considerations of speed.

As a gross sizing of the "electronic link" alternative during the "slow" R&D time frame, the corresponding transfer requirements are such as to engage the equivalent of approximately 5 data links of 1,200 bps capacity each, operating on a one shift, normal work week basis.

Because the driver is economics, not technology, system tradeoffs can exploit to the fullest special tariff structures and price breaks: e.g. discounts for off-time operation, quantity savings from use of bulk bandwidths, use of satellite links whenever transfer distance exceeds the cost breakpoint (currently or order 900 kilometers).

Analysis of Table 14.2 and 14.3 permits the inference that user services related to imagery manipulation--e.g. geocoding, superposition of formats, gridding--will impose significant technological requirements upon ADS. This is because low spatial resolutions are needed to satisfy the users.

TABLE 14.3

DATA SERVICE REQUIREMENT FOR THE NON-RENEWABLE RESOURCES DISCIPLINE

		LITHOLOGIC ASSESSMENT	GEOBOTANIC MINERAL EXPLANATION	GEOPHYSICAL/ RESOURCE EMPLACEMENT EVALUATION	GEOLOGIC STRUCTURE ASSESSMENT	ENGINEERING GEOLOGY
DATA LOCATION	Data Catalog	■	■	■	■	■
	Data Dictionary	■	■	■	■	■
	Computer Search	●	●	●	●	●
DATA EDITING	Quality Control	●	●	●	●	●
	Data Sorting	●	●	●	●	●
REFORMATTING	Form Conversion	●	●	●	●	●
	Code Conversion					
	Coordinate Conversion	●	●	●	●	●
	Scale Conversion					
ASSEMBLY	Data Segment Preparation					
	Data Set Preparation	●	●	●	●	●
DATA INTEGRATION	Single-Source Multi-temporal Data Registration					
	Single-Source Multi-temporal Data Merging					
	Multi-Source Uni-temporal Data Registration	■	■	■	■	■
	Multi-Source Uni temporal Data Merging					
	Data Gridding	●	●	●	●	●
	Data Overlay					
	Image Mosaicing					
SPECIAL PROCESSING	Radiometric Correction					
	Geometric Correction					
	Other					
DATA MGM'T	Data Archiving	●	●	●	●	●
	Data Delivery	1 ●	1 ●	1 ●	1 ●	1 ●
OTHER		2 ■	2 ■	2 ■	2 ■	2 ■

■ High Value Data Service ● Desirable Data Service

Note 1: 1 Month with Remote Terminal Access
2: Comprehensive Data Documentation

Users need to have available approximately 8 significant types of algorithms, Table 14.2. A potential evolutionary trend in the latter part of the 1980-1990 decade is the transition from user-peculiar development of these algorithms to their routine use--after the necessary confidence resulting from high "batting averages" will have been achieved.

Such an evolutionary development would open the ADS to the opportunity of providing a centralized algorithm processing function. Algorithms which reach fruition would be transferred to this function for conventional processing: the researcher would retain the function of developing the newer generations of algorithms.

14.3 Implications of ADS on the Non-Renewable Resources Discipline

The analysis of user requirements for the Non-Renewable Resources Discipline results in the following data-related findings:

- Current delivery times for remotely sensed data are adequate to support OSTA Non-Renewable Resources investigators.

- Data cost issues were not identified as a major concern by the users due to the primarily research nature of present investigations. Cost considerations were recognized as important issues in the eventual translation to a resource exploration pre-operational or technology transfer mode.

- Repetitive multispectral images are required to evaluate the seasonality of changes in landscape cover and select the times of the year for optimal display of cover types related to surface geology. Routine corrections for atmospheric effects and ground topography are required along with multisensor, multitemporal registration.

- Data applicable to non-renewable resources investigations are located in a variety of archives; there is no single point of contact to determine what data is available and how and where to obtain it. This requires investigators to familiarize themselves with a wide variety of data services, and results in significant inefficiencies with regard to the time required for investigators to locate, select and order data.

- ADS could improve upon the current state of data access by inventorying and cataloging the various sets of data appropriate to non-renewable resource investigations. Data should be retrievable on the basis of data type, geographic location (users request data referenced by latitude and longitude), and time. This service would speed data access and would enhance the investigator's awareness of data available to support his study. A data ordering and procurement service was also identified as a useful adjunct to the catalog and inventory service.

- Geoscientists rely on a broad spectrum of supplementary data products to extract non-renewable resource information from remotely sensed data, including aeromagnetic data, ground-based gravity data, geologic maps, etc. Most geoscientists are adept at dealing with such auxiliary data and gridding them to match remotely sensed data. However, they consider such tasks both costly and time consuming.

The Non-Renewable Resources Discipline users indicated a need for cost-effective and standardized data reformatting services including standards for georeferencing with respect to natural coordinate systems. Along with this reformatting and annotation service, the users recognized the need for a mosaicing service, particularly to accommodate use of adjacent swath wideth and multitemporal image data.

- The reconnaissance nature of the Non-Renewable Resources Discipline also makes it advantageous to provide an archive of processed intermediate products both to support multiple investigations and for historical analytic purposes.

In summary, the principal impact of an ADS upon the users of the Non-Renewable Resources Discipline would be enhancement of performance.

Key functions that would promote increased efficiency, in approximate priority are:

- A comprehensive data catalog to assist users in data selection and location both for primary and auxiliary data sets. A key feature of this catalog would be georeferencing of data contained.
- Establishment of a data ordering and procurement service.
- Radiometric correction of remotely sensed data for atmospheric effects and ground topography along with multitemporal, multi-sensor registration.
- Establishment of an archive of processed intermediate products both to support multiple investigations and for historic analysis.

15.1 Description of Objectives and Content

No single agency has overall responsibility for U.S. water resources. Functions of institutional water data gathering and water resources management are distributed among Federal and Local governmental bodies, principal among which are:

	PRECIPITATION RAIN/SNOW	WATER QUALITY	SURFACE WATER FLOW	GROUND WATER LEVEL	SNOW WATER EQUIVALENCY	FLOOD MAPPING	WETLANDS MAPPING	SNOWCOVER AREA	WATERBODIES INVENTORY	TURBIDITY SPOTTING	CURRENT PATTERN	IRRIGATED AREA
USGS		•	•	•		•						
SCS					•			•		•		
SEA		•	•									
FS	•	•	•		•			•				
NOAA	•		•					•			•	
BUREC		•	•	•					•			
COE		•	•		•	•		•	•			
EPA		•										
BPA	•		•		•			•				
TVA			•									
STATE		•	•			•	•			•		•
LOCAL		•	•			•	•			•		•

In addition to these operational activities, water resources agencies engage in research activities, primarily aimed at the development of hydrologic models of various types.

OSTA's Water Resources Discipline Program supports the activities of these agencies with a program directed toward the application of remote sensing technology to service the hydrologic information and modeling needs of these agencies.

OSTA's overall objective is to conduct research that will improve understanding of hydrology and ability to monitor, utilize, manage the components of hydrology that affect the balance of natural resources and human activities.

Current OSTA Program

OSTA's current Water Resources Discipline Program comprises four categories of R&D Activities:

WR 1 Measurement of Water Balance

Visible, microwave and thermal remote sensing data are used to determine hydrologic parameters to predict runoff, manage irrigation, and calculate water balance. Primary emphasis is on evaluating: microwave sensors for characterizing snowpack parameters; passive microwave techniques to measure surface and root zone soil moisture, depth of near-surface water table, watershed runoff coefficients; microwave analysis techniques to determine freeze-thaw lines, ice features, surface water area.

High resolution thermal, RBV data and simulated TM data are compared with existing visible and near IR data to test the added value of the former to water resources management.

Soil moisture information down to 10-15 cm is key to estimating the partition of rainfall into surface runoff and infiltration components; and of incoming solar energy into latent and sensible heat. It would also satisfy the requirements of the US-USSR bilateral agreement on microwave measurements of soil moisture.

Synoptic snowpack parameters augment conventional measurement techniques, generally deficient in terms of spatial and temporal coverage, for input to snowmelt and runoff models.

WR 2 Hydrologic Models

Models built around remotely sensed optical and microwave data are being developed to improve runoff prediction.

Improved snowpack models, now being developed, utilize available and projected satellite data for short term and seasonal snowmelt runoff forecasts. MSS and simulated TM data will be tested to ascertain the incremental improvement in runoff from the improved spatial, spectral and radiometric resolution.

More accurate runoff forecasts can result in improved management of water resources, of significant economic benefit.

Remote sensing has a high potential for providing: inputs to snowmelt runoff modeling; e.g. snow water equivalent, snow area, depth, free water content; and such parameters as soil moisture, imperviousness, freeze/thaw lines, soil groupings and landuse/landcover information.

WR 3 Surface Water Inventory

Development of techniques for locating and identifying water bodies and potential dam sites from LANDSAT imagery, and registering them by latitude, longitude, township and section will continue, aimed at near term technology transfer. Inferential techniques are being developed for determining the volume of these water bodies.

Inventory and location of dams assists state water managers to comply with Federal Dam Safety Assessment Laws, and to maintain an updated assessment of available water supplies.

WR 4 Water Requirements Assessment

The objectives are to: a) evaluate the utility of space-borne remote sensing to improved irrigation efficiency; b) develop further the most promising approaches; c) demonstrate how to use satellite data in representative areas; d) recommend improvements to satellite systems enhance their application to irrigation by federal, state, local agencies, private farming.

Agricultural irrigation accounts for 80% of the water consumed in the U.S. The increasing demand for water by agriculture, industry, and municipalities mandates that irrigation become more efficient. A 1976 GAO Report maintains that over one-half the water delivered to farms is wasted in overwatering. This can limit crop production, increase farming costs and contribute to water pollution.

Near Future OSTA Program

The program's philosophy is to perform scientific research on the uses of remote sensing to:

- foster understanding of the hydrologic cycle and to quantify storages and flows
- assist sister Agencies to improve water resources management operations.

The research elements of OSTA's near term Water Resources Discipline program are:

- research on irrigation scheduling using BuRec test sites.
- research on use of observation from LANDSAT-D, HCMM and TIROS for floodplain mapping, evapotranspiration estimation and agricultural meteorology.
- continued development of models and procedures for determining hydrologic land use and for developing improved hydrologic models using remotely sensed boundary conditions. A joint USDA/NASA Hydrologic Model Development Laboratory is planned for the betterment of the utilization of remotely sensed data.
- development and test of microwave detection and monitoring techniques to assess the presence of groundwater
- expansion of the technology of dam location to include estimates of reservoir volume
- coupling of the results of the research in flood plain mapping with those in hydrology to improve dynamic prediction of floods

The principal technology development efforts are expected to be:

- development of a dedicated mobile laboratory to measure properties of snowpacks
- test of the utility of the soil moisture satellite
- technology transfer of models of hydrologic response of ungaged areas based upon remotely sensed data

Future OSTA Program

Remote sensing techniques for monitoring snow and ice mapping, hydrologic land use, and determining the extent of surface waters are expected to have been established, thus will transition to operational use by Sister Agencies. Further refinements will be incorporated as better remotely sensed data becomes available in the visible, infrared and microwave portions of the spectrum from the RM, MRS, passive microwave or equivalent OSTA sensors.

Typical of these refinements is the adaptation of remote hydrologic techniques to the smaller watersheds which are the province of State and local users. These number in the tens of thousands. Because they are small, they require mapping of relatively fine resolution--TM or better. Because many are also densely populated; the chance of damage from errors is significant; thus they need hydrologic forecasts of high precision.

A major thrust of the program is expected to be represented by hydrologic measurements for agriculture, particularly soil moisture. Development of evapotranspiration models is planned to support soil moisture investigations.

Figure 15.1 presents a graphic synopsis of OSTA's Water Resources Discipline Program.

The first portion of the Figure reflects the space missions, current and projected, whose data products support the Program. The

FIGURE 15.1

WATER RESOURCE DISCIPLINE TIMELINE

OSTA MISSIONS

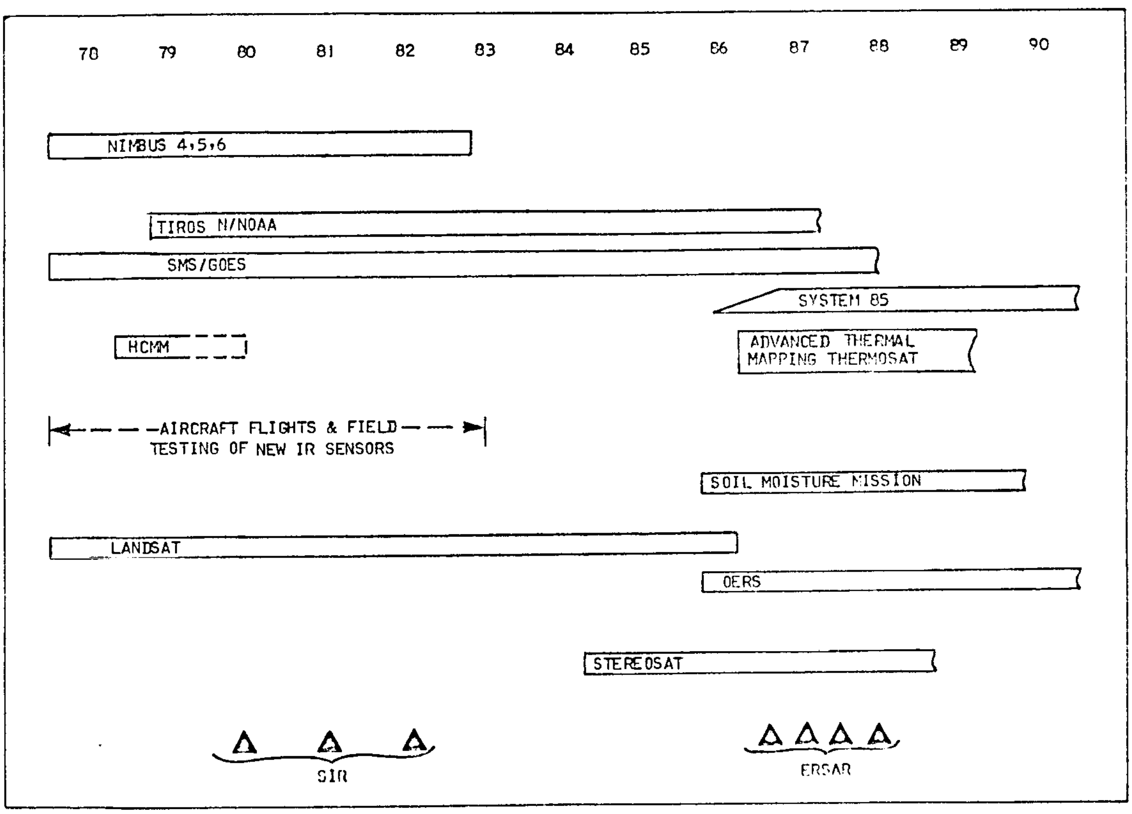
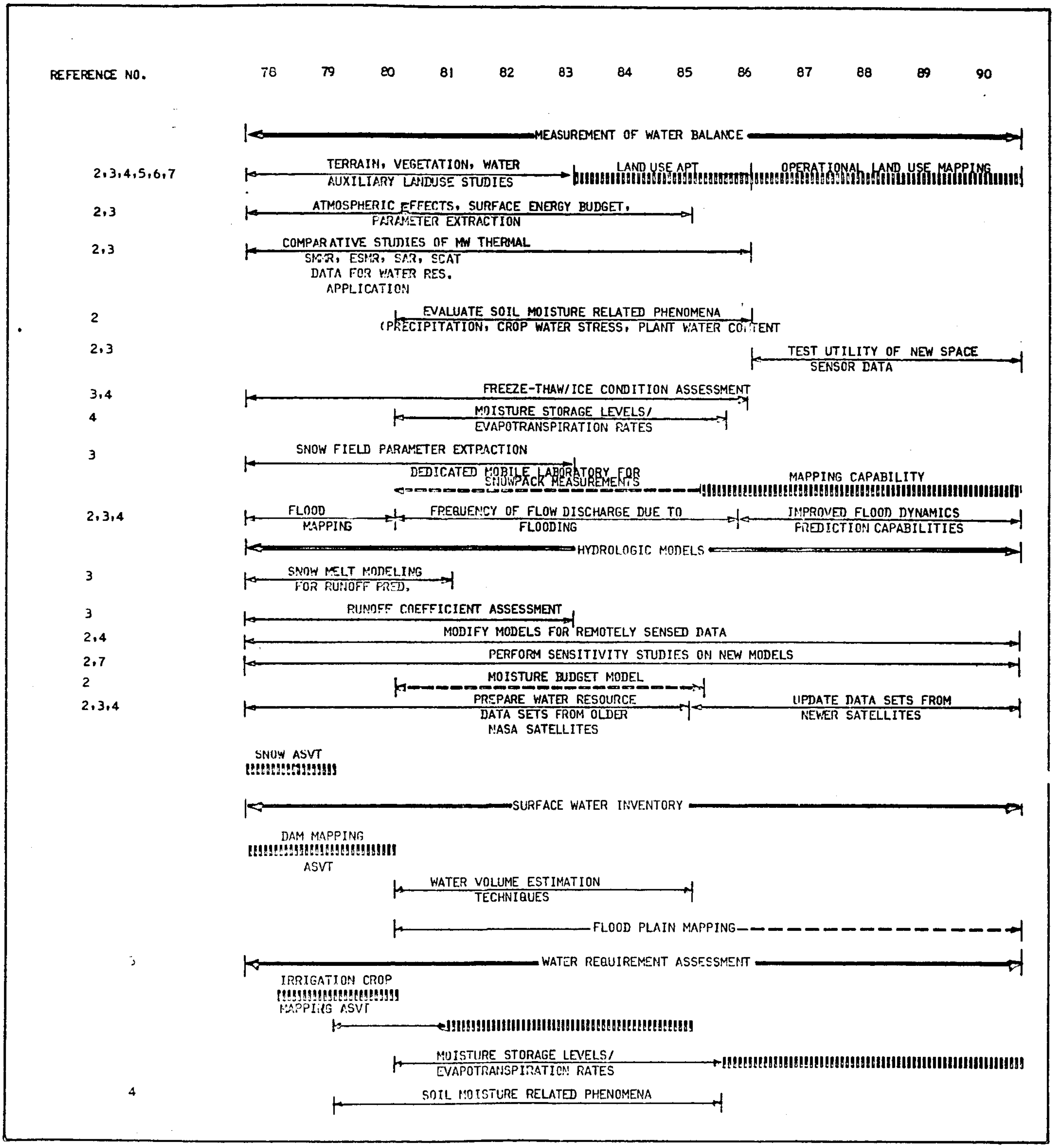


FIGURE 15.1

WATER RESOURCE DISCIPLINE TIMELINE

R & D ACTIVITIES



LEGEND

1 Flight Mission
2 Program Emphasis
3 R&D Activity
4 Continuing Activity
5 Technology Transfer (Pilot/Application Tests Etc.)
6 Short Term Event
7 Initial Operational Capability
8 All Investigation Classes

REFERENCES:

1) ENVIRONMENTAL OBSERVATION, 5 YEAR PLAN: FY 81'-85, 1979
2) RESOURCES OBSERVATIONS, 5 YEAR PLAN, 1979
3) RTOPS
4) OUTLOOK FOR SPACE 1980-2000: WATER RESOURCES
5) AN
6) RAP
7) ASVTS

subsequent portion and continuation sheet reflects the Program's endeavors for each identified R&D Activity.

Each element is referenced to its pertinent source documents; their titles are listed at the Figure's end.

15.2 Relationships between Data Services and the Water Resources Discipline

Figure 15.2 summarizes the requirements for data products expressed by the users.

Users are interested in obtaining parameters. These are intermediate information products derived from sensor measurements, elaborated via the application of appropriate algorithms. For example, snow surface temperature information derives from remotely sensed radiance data elaborated in conjunction with surface emissivity, atmospheric absorption, sensor calibration data.

NASA users in the Water Resources Discipline are in the process of developing such algorithms. For this purpose, they wish to receive raw space data, augmented by the auxiliary data summarized in Table 15.1

The volume of required space data remains approximately constant throughout the 1980-1990 decade, at approximately 20 Gigabits/year. The volume required of auxiliary data, from Table 15.1 is approximately one quarter that of the space data.

FIGURE 15.2

USER REQUIREMENTS FOR SPACE DATA PRODUCTS, WATER RESOURCES DISCIPLINE

	NOAA	LANDSAT		HCMM	SEASAT A		NIMBUS 7	SMS GOES	TIROS N		SHUTTLE	LANDSAT	STEREOSAT	SYSTEM 85			SOIL MOIST. SAT		THERMOSAT	OERS		SHUTTLE	
PARAMETERS	VTPR	RBV	MSS	HCMR	SMMR	SAR	SMMR	VISSR	AHVRR	TOVS	SIR	TM	STEREO-TELE-SCOPE	VISSR FOLLOW	AVHRR FOLLOW	ATMOS, SOUNDERS	MPMR	AMS	AHCMR	MRS	TM	ERSAR	
SOIL MOISTURE				O	O	O	O				O						O	O	O			O	
SNOW WATER EQUIVALENT					O		O										O	O	O				
SNOW DEPTH																		O					
SOIL TEMPERATURE	O			O	O		O	O	O					O	O		O		O				
ICE THICKNESS																		O					
SURFACE WATER EXTENT		O	O	O	O	O	O	O	O		O	O	O	O	O		O	O	O	O	O	O	
LAKE ICE EXTENT		O	O	O	O	O	O	O	O		O	O	O	O	O	O	O	O	O	O	O	O	
SURFACE AIR TEMPERATURE	O									O													
VERTICAL HUMIDITY PROFILE	O									O						O							
SNOW SURFACE TEMPERATURE														O	O								
VERTICAL WIND PROFILE														O									
SNOW COVER		O	O	O	O	O	O	O	O		O	O	O	O	O		O		O	O	O	O	
SNOW REFLECTANCE		O	O									O	O							O	O		
CLOUD COVER				O	O		O	O	O		O		O	O	O				O				
CLOUD TOP TEMPERATURE				O				O															
LAND COVER (MULTISPECTRAL REFLECTANCE)		O	O									O	O							O	O		
CROP CANOPY TEMPERATURE	O			O	O									O	O		O		O				
DATA BANKS																							
NOAA/NESS	O				O	O		O	O	O				O	O	O							
NCC/SDS	O							O	O	O				O	O	O							
EROS		O	O								O	O	O							O	O		
NSSDC				O			O				O						O	O	O			O	
SEASAT/CDHF					O	O																	
PRODUCT																							**PRODUCT TOTALS**
1980 TAPES/YR	12	140	24	192	25	10	25	-	190	-	-	-	-	-	-	-	-	-	-	-	-	-	598
1980 IMAGES/YR.	-	300	330	-	-	-	-	60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	740
1980 OTHERS/YR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1980 G BITS/YR.	0.2	5	1	6	1	0.4	1	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	21
1985 TAPES/YR.	-	-	-	-	-	-	-	-	176	20	34	96	-	60	20	-	152	90	242	360	-	-	1250
1985 IMAGES/YR	-	-	-	-	-	-	-	-	-	-	-	1520	32	-	-	-	-	-	-	840	-	-	2392
1985 OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1985 G BITS/YR.	-	-	-	-	-	-	-	-	6	1	1	3	-	2	1	-	5	3	9	13	-	-	44
1990 TAPES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	60	196	20	212	140	302	360	96	34	1420
1990 IMAGES/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	840	1520	-	2360
1990 OTHERS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1990 G BITS/YR.	-	-	-	-	-	-	-	-	-	-	-	-	-	2	7	1	7	5	11	13	3	1	50

TABLE 15.1

USER REQUIREMENTS FOR AUXILIARY DATA PRODUCTS, WATER RESOURCES DISCIPLINE

TYPE OF DATA	DATA PRODUCT FORMAT	SOURCE	ESTIMATED YEARLY PRODUCT VOLUME*					USE OF DATA PRODUCT
			WR 1	WR 2	WR 3	WR 4	TOTAL	
Soils Data	Soil classification maps (1:25,000 scale, typical) showing type, aerial extent and zonal thickness, etc.	USDA (CMC)	13	12	-	4	29	Combination with satellite measurement for evaluation of permeability and water storage capacity of watershed soils.
Topographic Data	Surface elevation maps (1:25,000 scale, typical)	NCIC USDA (CMC)	-	12	-	-	12	Evaluation of watershed boundaries and slopes for input to hydrologic models and verification/collection of satellite derived measurements.
	Digital (800 BPI) Earth Terrain Tapes of surface elevation data.	NCIC	-	6	-	-	6	
Runoff Data	Digital (800 BPI) Tapes of daily discharge data in cubic ft. per second at USGS stream flow gaging stations.	WATSTORE NAWDEX	-	12	-	-	12	Verification of satellite based hyrologic modeling results.
Snow Survey Data	Monthly SCS snow survey reports includes snowpack measurements obtained by aircraft of snow covered area, snow depth at aerial markers; by snow surveyers of snow depth, snow pack temperature, and snow water content.	SCS	39	36	-	-	75	Verification and calibration of satellite snow pack property measurements.

*Volume specified in number of individual products (Tapes, maps, reports....)

TABLE 15.1

USER REQUIREMENTS FOR AUXILIARY DATA PRODUCTS, WATER RESOURCES DISCIPLINE (CONT.)

TYPE OF DATA	DATA PRODUCT FORMAT	SOURCE	ESTIMATED YEARLY PRODUCT VOLUME*					USE OF DATA PRODUCT
			WR 1	WR 2	WR 3	WR 4	TOTAL	
Snow Survey Data (cont.)	Digital (800 BPI) Snowtel Data Tapes of snow pillow data (snow pack weight)	SCS	13	12	-	-	25	Verification and calibration of satellite snowpack property measurements.
Meteorologic Observations	Digital (800 BPI) Tapes of wind, air temperature, humidity and precipitation, cloud cover and cloud base height observations.	EDIS (NMC, NCC)	-	36	-	20	56	Evaluation of anticedent soil moisture conditions, snow pack, energy input, precipitation, etc. For input to hydrologic models.
Evaporation Data	Digital (800 BPI) Tapes of pan evaporation data.	EDIS (NCC)	13	12	-	4	29	Estimation of evaporation/evapotranspivation rates for input to hydrologic models.
Soil Moisture Data	Digital low density (800 BPI) Tapes of lipimeter data.	EDIS (NCC)	13	-	-	4	17	Verification of SMMR, SAR, HCMR, etc. soil moisture measurements.
Hydrologic Maps	Maps depicting watershed boundarys and surface water impoundments (1:25,000 scale typical)	NCIC	-	12	6	-	18	Verification of satellite derived water impoundment locations.

*Volume specified in number of individual products (Tapes, maps, reports....)

From Figure 15.1, OSTA's program is devoted to both research and technology transfer efforts throughout the 1980-1990 decade. Table 15.2 shows that the acceptable time lapse of data delivery for the research mode is of order four weeks.

Technology transfer activities could acquire two forms: 1) algorithms and models developed by NASA researchers are tested by other federal agencies upon their facilities, in this case NOAA's; or 2) they are tested on NASA facilities with participation from sister agency personnel.

The first form of transfer does not impact ADS because by current definition, ADS is intended to service NASA researchers only. In the second event, the timeliness requirements for data transfer would be of the order of days.

The inadequacy of current methods of data transfer has been demonstrated during the conduct of the GSFC-led Snow ASVT, Figure 15.1. Users needed to perform snowmelt forecasts every three to seven days: 30 days were required to obtain the corresponding LANDSAT imagery.

Thus, for research activities, ADS data transfer requirements can be satisfied by a service of data rate comparable to that of the U.S. mail.

It is anticipated that most of the technology transfer activities will be performed on facilities other than NASA's. These activities should thus have small impact on ADS.

TABLE 15.2

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: WATER RESOURCES

(OBSERVATIONS)

	R & D ACTIVITY			
	MEASUREMENT OF WATER BALANCE	HYDROLOGIC MODELS	SURFACE WATER INVENTORY	WATER REQUIREMENTS ASSESSMENT
REQUIREMENTS	WR 1	WR 2	WR 3	WR 4
Horizontal Resolution (KM)				
Minimum	0.01	.03	0.01	0.03
Maximum	0.6	500	0.3	0.1
Modal	0.08	.08	0.01-0.3	0.03-0.1
Vertical Resolution (km)				
Minimum	N.A.	.05	N.A.	N.A.
Maximum	N.A.	10	N.A.	N.A.
Modal	N.A.	0.5-10	N.A.	N.A.
Frequency				
Minimum	4 Weeks	4 Months	4 Weeks	4 Weeks
Maximum	1 Day	1 Day	1 Week	1 Week
Modal	1 Day	1 Day	1-4 Weeks	4 Weeks
Data Delivery				
Research Investigations	1-3 Months	4 Weeks	4 Weeks	4 Weeks
Technology Transfer	1-60 Days	3 Days-1 Month	3 - 80 Days	3 - 30 Days

TABLE 15.2 (cont'd)

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: WATER RESOURCES

(SPECIAL SERVICES)

	R & D ACTIVITY			
REQUIREMENTS	WR 1	WR 2	WR 3	WR 4
Format Satellite Data for Use with Vicar Software System	•			
Locate and Supply CCT's of Requested Satellite Data for Specified Geographic Locations and Time Periods	•	•		•
Maintain an Archive of Aircraft-Acquired Data	•			
Locate and Supply Aircraft and Auxiliary Data for Specified Geographic Locations and Time Periods		•		
Provide Satellite Data Mini Tapes for Specified Geographic Locations and Time Periods		•		•
Locate and Supply Landsat Imagery for Specified Geographic Locations and Times				
Format satellite data for Use with JSC Developed Computer Package "DAM"			•	

TABLE 15.2 (cont'd)

SUMMARY OF DATA PRODUCTS CHARACTERISTICS DESIRED BY THE USERS: WATER RESOURCES (STANDARD ALGORITHMS)

REQUIREMENTS	R & D ACTIVITY			
	WR 1	WR 2	WR 3	WR 4
Snowmelt Runoff	•	•		
Evapotranspiration	•	•		
Soil Moisture Profiles	•			
Thermal Response of Soil to Freeze	•			
Soil Water Equivalent		•		
Land Use Classification		•		
Surface Water Volume Estimator			•	
Crop Classification				•
Leaf Area Index				•
Biomass Estimators				•
Crop Moisture Stress Index				•

The slow data delivery requirements do not necessarily connote that electronic linkages are not desirable. They simply indicate that the choice of the link is driven by economic cost-effectiveness rather than by technical urgency. For example, a plausible ADS scenario may well incorporate a centralized accounting, scheduling and data traffic monitoring facility; which maintains track of expenditures on the part of the users, supplies them budgetary estimates, advises them of impending depletion of project funds. Further analysis might reveal that such centralized management function can be performed more cost-effectively through use of electronic data links than through other conventional alternatives; quite apart from considerations of speed.

As a gross sizing of the "electronic link" alternative, the corresponding transfer requirements are such as to engage the equivalent of approximately 3 data links of 1,200 bps capacity each, operating on a one shift, normal work week basis.

Because the driver is economics, not technology, system tradeoffs can exploit to the fullest special tariff structures and pricebreaks: e.g. discounts for off-time operation, quantity savings from use of bulk bandwidths, use of satellite links whenever transfer distance exceeds the cost breakpoint (currently of order 900 kilometers).

Analysis of Table 15.2 and 15.3 permits the inference that user services related to imagery manipulation---e.g. geocoding, superposition of formats, gridding---will impose stringent technological requirements upon ADS. This is because high spatial resolutions are needed to satisfy the users.

TABLE 15.3

DATA SERVICE REQUIREMENTS FOR THE WATER RESOURCES DISCIPLINE

		MEASUREMENT OF WATER BALANCE	HYDROLOGIC MODELING	WATER SUPPLY INVENTORY	WATER REQUIREMENTS ASSESSMENT
DATA LOCATION	Data Catalog	■	■	■	■
	Data Dictionary	■	■	■	■
	Computer Search	●	●	●	●
DATA EDITING	Quality Control	●	●	●	●
	Data Sorting	●	●	●	●
REFORMATTING	Form Conversion	■	■	■	■
	Code Conversion				
	Coordinate Conversion				
	Scale Conversion				
ASSEMBLY	Data Segment Preparation	●	●	●	●
	Data Set Preparation	●	●	●	●
DATA INTEGRATION	Single-Source Multi-temporal Data Registration	■	■	■	■
	Single-Source Multi-temporal Data Merging				
	Multi-Source Uni-temporal Data Registration	■	■	■	■
	Multi-Source Uni temporal Data Merging				
	Data Gridding	●	●	●	●
	Data Overlay	●	●	●	●
	Image Mosaicing				
SPECIAL PROCESSING	Radiometric Correction	●	●	●	●
	Geometric Correction	●	●	●	●
	Other				
DATA MGM'T	Data Archiving				
	Data Delivery	1■	1■	1■	1■
OTHER		2■	2■	2■	2■

■ High Value Data Service ● Desirable Data Service

Note 1: Real Time to One Week for Tech. Transfer with Remote Terminal Access

Note 2: Comprehensive Data Documentation

Users need to have available approximately 12 significant types of algorithms, Table 15.2. A potential evolutionary trend in the latter part of the 1980-1990 decade is the transition from user-peculiar development of these algorithms to their routine use-after the necessary confidence resulting from high "batting averages" will have been achieved.

Such an evolutionary development would open the ADS to the opportunity of providing a centralized algorithm processing function. Algorithms which reach fruition would be transferred to this function for conventional processing: the researcher would retain the function of developing the newer generations of algorithms.

15.3 Implications of ADS on the Water Resources Discipline

The analysis of the user requirements for the Water Resource Discipline yields the following data-related points:

- Current data delivery rates experienced by OSTA Water Resources investigators are on the order of two weeks to 1 month for space data products through EROS and NSSDC; and on the order of 1 to 3 months through EDIS for most auxiliary data products. These delivery rates are too slow for technology transfer activities. For example, the ASVT on Operational Applications of Satellite Snow Cover Observations requires surface hydrology parameters, derived from satellite data, within approximately 72 hours and meterologic data within 1-3 hours.

- Most other Water Resources Research Activities do not have such critical delivery requirements: researcher desires are for delivery rates of order 1 to 2 weeks

- Data Product costs are felt to be an important constraining factor in OSTA Water Resource efforts. Research time schedules and budgetary constraints are such that attention must be given to improving the time and cost-effectiveness of data access, particularly as these impact cooperative users.

  Investigators currently spend considerable time researching data applicable to their particular endeavor. Concensus within the Hydrology panel of the Data Systems Workshop is that the cost and time requirements of research activities could be reduced through provision of a comprehensive Data Catalog service. Through such a service a user could be made quickly and easily aware of all available data and their locations. This data should be retrievable by subject, geographic location, and time. Characteristics of the data should be indicated, e.g. level of processing, quality, scale. The Water Resources Catalog and Directory should link into existing water resource data bases such as WATSTORE and NAWDEX; this may require considerations for commonality of services between data bases.

- Many operational users who participate in OSTA Technology Transfer activities cannot take full advantage of the space data products made available, due to time and cost conisderations as indicated above, and due to problems encountered with processing and formatting of data products. Remotely sensed data products are viewed by operational users as supportive and complementary to the more readily understood and handled conventional hydrologic data sets. Increased emphasis should be devoted to converting satellite data products into conventional hydrologic

- data set formats to aid both internal and external users. Satellite products should be processed and georeferenced in accordance with the conventional data products which they supplement. An example of such a product is the Basin snow cover maps prepared by NOAA/NESS from SMS/GOES observations, used to support operational snow survey forecasting in the Western U.S.

- Research users experience problems associated with product format, particularly those whose activities include utilization of image processing systems such as the AOIPS or VICAR systems. Significant time and money is spent in reformatting satellite products for use with these systems. These systems, being implemented on small scientific computers, do not have the capacity for full frame data storage. Consequently, mini-tapes should be prepared for use with the systems from the standard satellite CCT's. Moreover, the data on mini-tapes should be in band-sequential format rather than the standard Landsat CCT's band-interleaved format.

- NASA users in the Water Resources Discipline are oriented towards satisfying the near-term requirements of "external" users. This "External" orientation strongly suggests that archival storage of system corrected, parameterized and geo-referenced data be made available. Accordingly, continuous, updated and pedigree-annotated data catalogs and directories should be made available. This capability will significantly improve data delivery to users and aid in providing integrated data sets, required due to the complexities of the hydrologic phenomena involved. It is most likley that common format data sets will be required in the future, probably along the lines of the USGS quad sheets. Data sets for key Water Resources units e.g., basins will also be required and could form an important data set product available from an ADS service.

In summary, the principal impact of an ADS upon the users of the Water Resources Discipline would be economic, i.e. significant reduction in the time and cost involved in generating comprehensive data sets.

Five key functions would promote increased efficiency. In approximate priority:

- A comprehensive data catalog with georeferencing and data pedigree
- Georeferencing of remotely sensed data in accordance with the conventional data products they are to supplement
- Data segment preparation and reformatting services
- Archival of systems corrected, parameterized and georeferenced data
- Acceleration of data delivery times to support operational water resource technology demonstrations

16. SYSTHESIS OF USER REQUIREMENTS FOR ADS

This section integrates the results of the user requirements study for the thirteen disciplines comprising OSTA's current and future program. The key results are presented in five categories summarizing the requirements for space derived products, space derived parameters, auxiliary data products, data transfer and data services.

Space Derived Product Requirements

Table 16.1 summarizes the quantity of space derived products required for the thirteen disciplines for the current (1980), near term (1985) and future (1990) time frames. The table gives the numbers of digital tapes, corresponding gigabits, and images required by the users from spaceborne sensors expected to be available.

The Table's key points are:

- The volume of digital data products is relatively constant to 1985. The projected 250% increase by 1990 is paced by the Agriculture, Forestry and Rangeland (AFR) Discipline.

- The largest share of the data products, climbing from 34% of all requirements in 1980 to 68% in 1990, is also induced by AFR.

  Dominance by the AFR Discipline is attributed to the fact that this discipline is projected to reach an advanced state of technology transfer and will continue to utilize primarily NASA service facilities.

- The 1980-1985 time frame exhibits a high demand for images, which reduces significantly by 1985. This is due to the gradual reduction of the use of image products by the AFR users who indicate

TABLE 16.1

ADS REQUIREMENTS SUMMARY - ALL DISCIPLINES

		GLOBAL WEATHER	CLIMATE	SEVERE STORMS	AIR QUALITY	OCEAN PROCESSES	COASTAL ZONE	CRYOSPHERE	WATER QUALITY	AGRICULTURE, FORESTRY RANGELAND	WATER RESOURCES	LAND USE	NON-RENEWABLE RESOURCES	GEODYNAMICS	TOTAL
1980	TAPES/YR.	1566	3362	4071	630	2984	2856	358	130	9308	598	977	1054	477	28391
	TAPE SEGMENTS/YR.	-	-	-	-	-	-	-	-	8160	-	-	-	-	8160
	IMAGES/YR.	-	-	-	100	-	-	-	240	16019	740	1810	292	-	19201
	IMAGE SEGMENTS	-	-	-	-	-	-	-	-	400	-	-	-	-	400
	FILMSTRIPS/YR.	-	-	-	-	30	360	-	-	-	-	-	-	-	390
	G BITS/YR.*	55	118	142	22	104	100	13	5	329	21	34	37	17	997
1985	TAPES/YR.	3070	4892	5307	790	3509	304	289	385	8017	1250	1601	1173	429	31016
	TAPE SEGMENTS/YR.	-	-	-	-	-	-	-	-	2565	-	-	-	-	2565
	IMAGES/YR.	-	-	-	100	-	-	-	300	3089	2392	1076	514	81	7552
	IMAGE SEGMENTS	-	-	-	-	-	-	-	-	400	-	-	-	-	400
	FILMSTRIPS/YR.	-	-	-	-	20	40	10	-	-	-	-	-	-	70
	G BITS/YR.*	107	171	186	28	123	11	10	13	283	44	56	41	15	1088
1990	TAPES/YR.	3090	5157	6186	550	4287	731	463	375	48604	1420	1532	1330	445	74188
	TAPE SEGMENTS/YR.	-	-	-	-	-	-	-	-	1640	-	-	-	-	1640
	IMAGES/YR.	-	-	-	100	-	-	-	450	7746	2360	1065	615	81	12417
	IMAGE SEGMENTS	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	FILMSTRIPS/YR.	-	-	-	-	20	60	10	-	-	-	-	-	-	90
	G BITS/YR.*	108	181	216	19	150	26	16	13	1702	50	54	47	16	2598

*1 G Bits = 1,000,000,000 Bits

that the trend is toward digital processing. The use of images in the Non-Renewable Resources (NRR) Discipline doubles by 1985. This is attributed to the reconnaissance nature of the NRR activities.

- The trend in Land Use and Water Quality is also toward digital processing. During the 1980-1985 time frame images account for ≃65% of products by number. By 1985 this percentage drops to ≃40% and remains relatively constant to 1990.

- The increase in the demand for digital data over time reflects the increased sensor resolution of the level 1 products.

Space Derived Parameter Requirements

The analysis shows a strong and growing trend toward the use of parameters. Most users wish to retain control of the development of algorithms for converting data into parameters. The development of such conversion algorithms drives OSTA's activities up to 1985-87.

The relationship between the OSTA disciplines, the parameters sought by the users and the space data generators is included in chart form in the pocket at the back of this report.

As shown in the chart, 137 parameters were identified in the analysis. Each parameter is used on the average by 4 disciplines. Commonalities are evident: on the average, a parameter is shared by four disciplines.

- Commonality of parameters among the thirteen disciplines portends potential benefits from a *centralized data service* which provides parameters to multi-disciplinary users.

The chart also shows that the parameters sought remain substantially invariant. What does change are the sensor's characteristics: i.e. the parameters are measured more prefectly as time progresses.

- The continuous existence of common parameters throughout the 1980-1990 time frame implies that *investment by ADS in an algorithm-processing service* should be cost-effective.

Auxiliary Data Product Requirements

Table 16.2 summarizes the volume of auxiliary products required to support the OSTA users.

It specifies the requirements for digital tapes by density i.e. 1600, 800, 556 BPI and the needs for photographic and hardcopy products. Products such as maps, computer printouts, reports and microfilmed records are included within the hardcopy products catagory. The table's key points are:

- The volume of auxiliary data is approximately 30% that of the space data for this 1980-1985 time period. It increases to 50% by 1990.

- The Agriculture, Forestry and Rangeland discipline is the primary user of auxiliary data, accounting for 73% of the requirements in the 1980-1985 time frame, increasing to 90% by 1990.

- The Severe Storms and Climate disciplines are also significant users: 16% of the volume in the 1980-1985 time frame.

ADS AUXILIARY DATA REQUIREMENTS SUMMARY - ALL DISCIPLINES

	GLOBAL WEATHER	CLIMATE	SEVERE STORMS	AIR QUALITY	OCEAN PROCESSES	COASTAL ZONE	CRYOSPHERE	WATER QUALITY	AGRICULTURE, FORESTRY RANGELAND	WATER RESOURCES	LAND USE	NON-RENEWABLE RESOURCES	GEODYNAMICS	TOTAL
TAPES/YR. (1600 BPI)	300	38	788	14	13	12	13	0	1446	0	0	0	0	2624
TAPES/YR. (800 BPI)	137	517	489	138	50	56	39	71	10697	145	72	73	224	12708
TAPES/YR. (556 BPI)	0	420	0	0	122	102	160	0	0	0	0	0	0	804
PHOTOS/YR.	0	0	0	0	0	0	0	0	0	0	220	0	0	220
HARDCOPY	15	53	0	88	1	44	293	143	3310	134	158	77	61	4377
G BITS/YR.	13	15	36	3	3	3	3	1	238	3	1	1	4	324
TAPES/YR. (1600 BPI)	584	55	1043	18	15	1	10	0	1232	0	0	0	0	2958
TAPES/YR. (800 BPI)	267	749	647	176	59	6	30	185	9113	304	119	81	198	11934
TAPES/YR. (556 BPI)	0	609	0	0	144	11	123	0	0	0	0	0	0	887
PHOTOS/YR.	0	0	0	0	0	0	0	0	0	0	362	0	0	362
HARDCOPY	29	77	0	112	1	5	225	372	2820	281	260	85	54	4321
G BITS/YR.	25	22	48	4	3	0	2	3	203	5	2	1	3	321
TAPES/YR. (1600 BPI)	589	58	1204	12	19	3	16	0	7448	0	0	0	0	9349
TAPES/YR. (800 BPI)	269	789	747	119	72	15	48	185	55101	345	114	93	211	58108
TAPES/YR. (556 BPI)	0	641	0	0	176	27	197	0	0	0	0	0	0	1041
PHOTOS/YR.	0	0	0	0	0	0	0	0	0	0	349	0	0	349
HARDCOPY	29	81	0	76	1	11	361	372	17050	319	251	98	57	18706
G BITS/YR.	25	24	55	3	4	1	4	3	1225	6	2	2	4	1358

Table 16.3 shows the data bases identified in the analysis. It shows that most data bases serve multiple disciplines: many already possess, or are evolving towards the capability for electronic inquiry. By 1985, most major data repositories are contemplating various levels of automated data delivery. This does not mean that historical data will be necessarily digitized: most of the data provided will be of current vintage.

In general, the data will be supplied in the batch mode. Most data bases provide only restricted access: this should however not pose a significant restriction to NASA access.

Directory and access services for a significant number of data bases is through three principal existing auxiliary data banks: EDIS, USGS National Center, NAWDEX.

Data Transfer Requirements

The user requirements for data transfer are of order two to four weeks for research efforts and from hours to days for activities related to transfer of technology.

Current data delivery times are of order one to three months. Note however that most of the current delay is attributable to internal response times. These will presumably be significantly reduced as data bases increasingly become automated in accordance with currently established plans.

TABLE 16.3

REMOTE DATA ACCESS CAPABILITIES OF THE DATA BANKS SERVING THE ADS DISCIPLINES

	AGRICULTURE	AIR QUALITY	CLIMATE	COASTAL ZONE	CRYOSPHERE	GEODYNAMICS	LAND USE	NON-RENEWABLE RESOURCES	OCEAN PROCESSES	SEVERE STORMS	WATER QUALITY	WATER RESOURCES	GLOBAL WEATHER	REMOTELY ACCESSIBLE DATA DIRECTORY	REMOTE DATA DELIVERY
Goddard Institute of Space Science (GISS)	●													R	R
Goddard Space Flight Center, Image Processing Division (GSFC/IPD)	●	●	●	●	●		●	●	●	●	●	●	●	R	R
Goddard Space Flight Center Very Long Baseline Interferometry System (GSFC/VLBI Systems)						●								D	D
Johnson Space Center, Agricultural Weather Forecasts (JAWF)	●													R	R
Jet Propulsion Laboratory Seasat Central Data Handlins Facility (JPL/SEASAT CDHF)			●	●	●	●	●	●	●	●		●		R	R
Jet Propulsion Laboratory Very Long Baseline Interferometry System (JPL/VLBI Systems)						●								N	N
Johnson Space Center Global Agronomic Data Base (JSC/GADB)	●													R	R
Aircraft Flight Programs NASA/JPL-WFC	●													N	N
National Space Science Data Center (NSSDC)	●	●	●	●	●	●	●	●	●	●	●		●	N	N
UARS Central Data Handling Facility UARS CDHF		●	●											R	R
DMSP Satellite Data Library (DMSP)				●					●					R	R
Earth Resources Observation System Data Center (EROS)	●	●	●	●		●	●	●			●	●		R	R
European Space Operations Center, Data Services (ECOS)													●	N	N
National Climatic Center, Space Data Services Branch (NCC/SDS)	●	●	●	●	●				●	●		●	●	R	R
NOAA, National Environmental Satellite Service (NOAA/NESS)	●	●	●	●	●		●	●	●	●	●	●	●	R	R
National Oceanic Satellite System, Primary Processing Facility (NOSS/PPF)			●	●	●	●		●	●	●	●		●	R	R

D - Dial-up Service Available
R - Restricted Access
N - Capability Does Not Exist
● - Discipline Served

TABLE 16.3

REMOTE DATA ACCESS CAPABILITIES OF THE DATA BANKS SERVING THE ADS DISCIPLINES

	AGRICULTURE	AIR QUALITY	CLIMATE	COASTAL ZONE	CRYOSPHERE	GEODYNAMICS	LAND USE	NON-RENEWABLE RESOURCES	OCEAN PROCESSES	SEVERE STORMS	WATER QUALITY	WATER RESOURCES	GLOBAL WEATHER	REMOTELY ACCESSIBLE DATA DIRECTORY	REMOTE DATA DELIVERY
NASA/JSC AIRP-AID	●													R	R
National Cartographic Information Center (NCIC)	●						●	●						R	R
National Center for Atmospheric Research		●	●										●	R	R
National Climatic Center (NCC)	●	●	●	●	●			●	●	●	●	●	●	R	R
National Geodetic Data Base						●								R	D
National Geophysical and Solar Terrestrial Data Center (NGSDC)			●			●			●					R	N
National Hurricane Center (NHC)									●	●			●	R	R
U.S. Air Force Environmental Technical Application Center (USAFETAC)			●							●			●	R	R
U.S. Coast Guard Oceanographic Unit (USCG)										●			●	D	D
USDA/Economics, Statistics and Cooperative Service (USDA/ESCS)	●													R	D
USDA Foreign Agriculture Service (USDA/FAS)	●													N	D
USDA Scientific and Education Administration (USDA SEA)	●											●		N	D
USDA Soil Conservation Service (USDA/SCS)	●		●		●			●				●		N	R
USDA Forest Service USDA/FS)	●											●		R	R
USDA Agriculture, Stabilization & Conservation Service (USDA/ASCS)	●						●	●						R	D
Electric Power Research Institute (EPRI)		●												N	N
Fleet Numeric Weather Central (FNWC)			●		●				●	●			●	R	R
Fleet Weather Facility (FWF)					●				●				●	R	R
USGS/Geolab						●								R	R
GISS	●													R	R
JAWF	●													N	N
JSC/Agristars Data Base	●													R	R
LARS	●													R	R
Office of Water and Hazardous Materials (STORET)	●	●									●	●		R	R

D - Dial-up Service Available
R - Restricted Access
N - Capability Does Not Exist
● - Discipline Served

TABLE 16.3 (cont'd)

REMOTE DATA ACCESS CAPABILITIES OF THE DATA BANKS SERVING THE ADS DISCIPLINES

	AGRICULTURE	AIR QUALITY	CLIMATE	COASTAL ZONE	CRYOSPHERE	GEODYNAMICS	LAND USE	NON-RENEWABLE RESOURCES	OCEAN PROCESSES	SEVERE STORMS	WATER QUALITY	WATER RESOURCES	GLOBAL WEATHER	REMOTELY ACCESSIBLE DATA DIRECTORY	REMOTE DATA DELIVERY
Air Force Global Weather Central (AFGWC)			●						●	●			●	R	R
California Institute of Technology						●								R	R
Center for Climatic and Environmental Assessment (CCEA)			●											R	N
Current Research Information System (CRIS)	●													D	D
Defense Mapping Agency Topographic Center (DMATC)	●					●	●	●						R	R
Bureau of Census, User Services Office							●							N	N
EPA Environmental Research Center (EPA/ERC)		●												R	D
National Marine Fisheries Service (NMFS)			●	●	●				●		●		●	D	D
National Meteorologic Service (NMC)	●		●						●	●			●	R	R
National Oceanographic Data Center (NODC)			●	●					●		●		●	R	D
National Severe Storm Forecast Center (NSSFC)										●			●	R	D
National Severe Storm Laboratory										●			●	N	N
NOAA/Data Buoy Office (NBDO)									●				●	N	R
National Water Data Exchange (NAWDEX)											●	●		R	R
SEDIC														N	N
Scripps Institute of Oceanography									●					N	N
Tamu Crop Spectra Data Base (TAMU)	●													R	R
USGS Office of Resource Analysis (USGS/ORA)								●						R	R
USGS Rock Analysis Storage System (USGS/RASS)								●						R	R
USGS Water Storage Coordination Office (WATSTORE)								●			●	●		R	R
U.S. Weather Service							●			●		●	●	R	R
Weslaco Crop Spectra Data Base	●													N	N
Woods Hole Oceanographic Institute (WHOI)				●					●					N	N

D - Dial-up Service Available
R - Restricted Access
N - Capability Does Not Exist
● - Discipline Served

TABLE 16.3 (cont'd)

Note: Access to a significant number of the Non-NASA data banks listed can be made through three principal data services:

- NAWDEX - Central point of access for most federal and non-federal water data banks such as STORET, WATSTORE, and various state and private data banks.
- USGS National Center - Central point of access to most USGS data services including EROS, NCIC, WATSTORE, and many smaller but frequently used data bases.
- EDIS - The Environmental Data and Information Service of NOAA provides computerized referral to available environmental sciences data at NCC, NODC, NGSDC and many other NOAA-operated data banks.

By 1990, research activities account for approximately 75% of the data load. They could in theory be handled by mail type data transfer service. The slow data delivery requirements of the research activities do not necessarily connote that electronic linkages are not desirable. They simply indicate that the choice of the link is driven by economic cost-effectiveness rather than by technical urgency. For example, a plausible ADS scenario may well incorporate a centralized accounting, scheduling and data traffic monitoring facility; which maintains track of expenditures on the part of the users, supplies them budgetary estimates, advises them of impending depletion of project funds. Further analysis might reveal that such centralized management function can be performed more cost-effectively through use of electronic data links than through other conventional alternatives: quite apart from considerations of speed.

A gross sizing of the "electronic link" alternative is provided by Tables 16.4 and 16.5.

TABLE 16.4

ALLOCATION OF PRODUCT DATA FLOW FOR SPACE AND AUXILIARY DATA AVAILABLE IN DIGITAL FORMAT

(Equivalent 1200 BPS Links, One Shift, Normal Work Week)

	1980	1985	1990
GSFC	70	83	92
JSC	73	62	376
JPL	19	21	25
LaRC	4	6	5
NSTL	4	7	7

TABLE 16.5

DISCIPLINE/CENTER ALLOCATION OF PRODUCT DATA FLOW FOR

SPACE AND AUXILIARY DATA AVAILABLE IN DIGITAL FORMAT - 1980, 1985, 1990

(Equivalent 1200 BPS Links, One Shift, Normal Workweek)

	GSFC			JSC			JPL			LaRC			NSTL		
DISCIPLINE	1980	1985	1990	1980	1985	1990	1980	1985	1990	1980	1985	1990	1980	1985	1990
AIR QUALITY										3	4	3			
CLIMATE	15	22	23												
COASTAL ZONE	12	2	3												
CRYOSPHERE	2	2	3												
GLOBAL WEATHER	8	15	15												
OCEAN PROCESSES							12	14	18						
SEVERE STORMS	20	26	31												
WATER QUALITY										1	2	2			
AGRICULTURE, FORESTRY, RANGELAND				63	54	326									
GEODYNAMICS	3	3	3												
LAND USE													4	7	7
NON-RENEWABLE RESOURCES							5	5	6						
WATER RESOURCES	3	6	7												
TOTAL	63	76	82	63	54	326	17	19	24	4	6	5	4	7	7

* Number of Links = (data bits per year) ÷ (seconds per year) ÷ (1200 BPS per link)

Since the driver is economics, not technology, system tradeoffs can exploit to the fullest special tariff structures and price breaks: e.g. discounts for off-time operation, quantity savings from use of bulk bandwidths, use of satellite links when transfer distance exceeds the cost breakpoint (currently of order 900 kilometers).

By 1990, technology transfer activities account for approximately 25% of the data load. These latter could acquire two forms: 1) algorithms and models developed by NASA researchers are tested by other federal agencies upon their facilities; or 2) they are tested on NASA facilities with participation from sister agency personnel.

The first form of transfer does not impact ADS because by current definition, ADS is intended to service NASA researchers only. In the second event, the timeliness requirements for data transfer approach real time. It is, however, important to distinguish between the direct transfer of space data from satellite to users, and the transfer to users of archival data. Only the latter is within the purview of ADS as currently defined.

Typical of the applications posing the most stringent requirements are agricultural early warning, and activities associated with crop production forecasting. The timings of the corresponding physical observables are such as to give rise to short periods of intense interest, interspersed by longer intervals of lesser importance. The occurrence of frosts is a typical case in point: indicative crop change occurs within hours, at most a few days after the frost event; thereafter the "indicators," pointing to either recovery or loss, vary but slowly.

The net result is that these activities impact ADS by imposing conditions of high peak transfer rates at low duty cycles. As a gross sizing, peak-to-average ratios are expected to reach 5:1.

ADS systems tradeoffs can exploit the significant difference between the "slow" R&D and the "fast" Technology Transfer requirements through the use of load-evening techniques, such as priority scheduling.

Data Service Requirements

Table 16.6 summarizes the user response to the need for data services. The numbers indicate the percentage of users within each discipline specifying the data services shown on the corresponding row. Figure 16.1 integrates this information across disciplines: the user requirements are weighted by the number of users served, assigning equal weight to each discipline user.

The key points indicated by the Figure are:

- ADS services universally required are:
  - = data directory services
  - = data dictionary
  - = preassembly of data sets from multiple sources

- Second priority services are:
  - = extraction of selected data subsets from available data sets, for both space and auxiliary data products.
  - = assembly of multitemporal data sets

  Users expressed significant demand for individual terminals. Approximately half of these should be interactive; a substantial fraction should be of the "smart" variety.

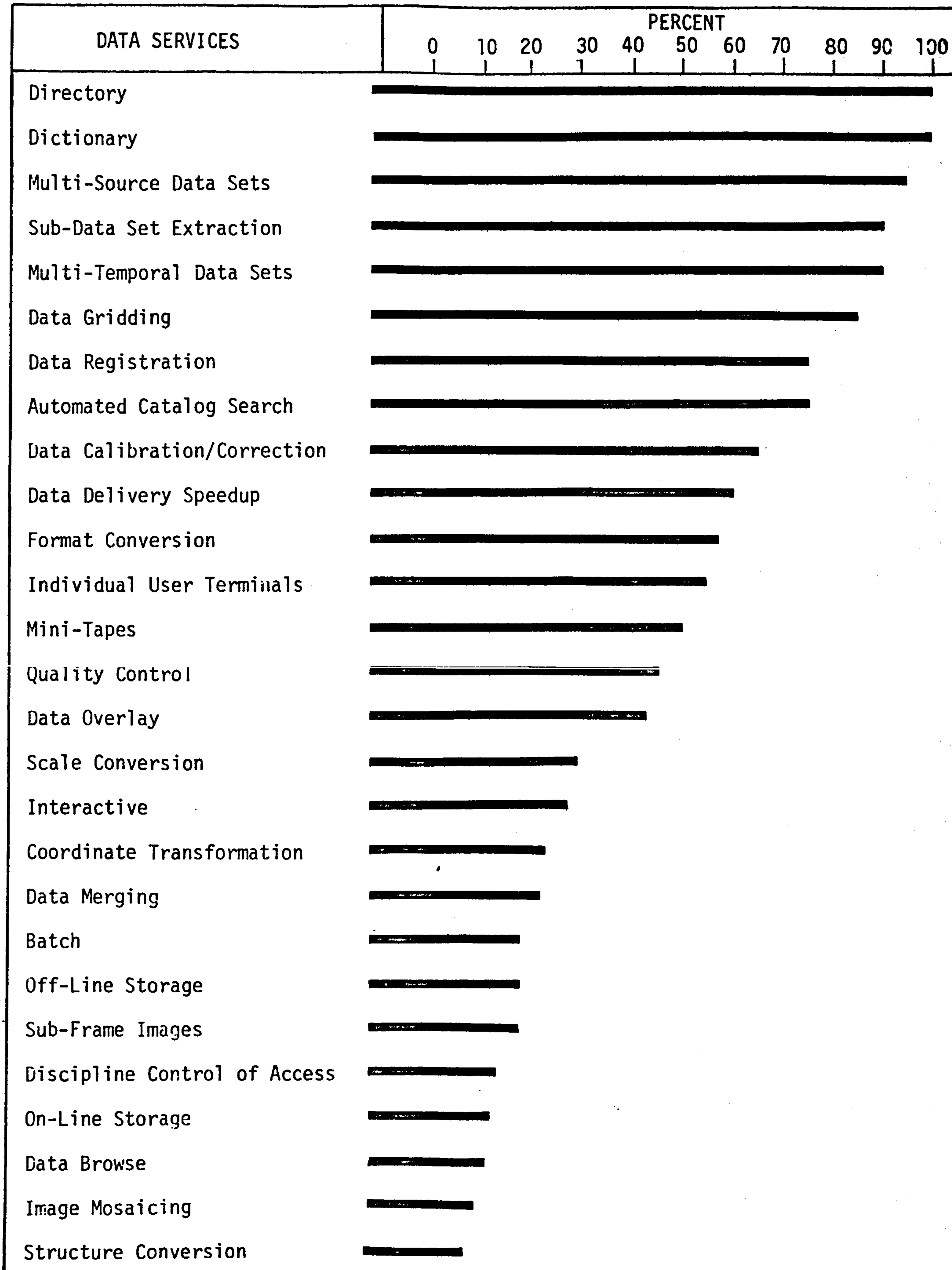
SUMMARY OF DATA SERVICES* REQUIRED BY OSTA INVESTIGATORS WITHIN THE THIRTEEN ADS DISCIPLINES

DATA SERVICES*	PERCENT OF DISCIPLINE INVESTIGATORS REQUIRING THE SERVICE												
	AIR QUALITY	CLIMATE	COASTAL ZONE	CRYOSPHERE	GLOBAL WEATHER	OCEAN PROCESSES	SEVERE STORMS	WATER QUALITY	AGRICULTURE, FORESTRY, RANGELAND	GEODYNAMICS	LAND USE	NON-RENEWABLE RESOURCES	WATER RESOURCES
User Access Mode													
Batch								35		100		100	
Interactive	100	100					100						
Individual User Terminals	100		96	75	100	78	100			100		100	100
Data Management													
Data Documentation													
Directory	100	100	100	100	100	100	100	100	100	100	100	100	100
Dictionary	100	100	100	100	100	100	100	100	100	100	100	100	100
Data Storage													
On-Line	100												
Off-Line		100		20		22	96						
Product Control													
Quality Control		11	100	80		100				100	100	100	100
Data Access Services													
Data Query													
Automated Catalog Search	100	100	100	80		100		100		100	100	100	100
Data Browse		100											
Data Delivery Speedup			95	75	100	78	100	100		100	100	100	100
Value Added Services													
Data Segment Preparation													
Sub-Frame Images									100				
Mini-Tapes		11	100	80	60	61	100	100	100				100
Sub-Data Set Extraction	100	70	100		60	100	96	100	100	100	100	100	100
Reformatting													
Format Conversion			100	100	25	74	92	100		100	100	100	100
Structure Conversion					25		92						
Coordinate Transformation		11			25	22	92			100	9	100	
Scale Conversion									100	37	100		
Data Set Preparation													
Multi-Source Data Sets	100	91	100	80	100	100	96	100	100	100	100	100	100
Multi-temporal Data Sets	100	91	96	75	100	100	96	100	100	100	100		83
Data Integration													
Data Merging	22	36		100	85						100		
Data Registration	58	68	96	20	40	100	100	100	47	73	100	100	100
Data Overlay	33	59			15				00		100		100
Data Gridding	100	100	85	95	100	100	96	100		100	100	100	100
Image Mosaicing											100		
Special Processing													
Data Calibration/Correction	100	20	100	80	100	78	4	100	86		100		100
Discipline Control of Access	20										100		

*Services listed are not necessarily unique.

FIGURE 16.1

SYNOPSIS OF DATA SERVICE REQUIREMENTS - ALL DISCIPLINES



Users place significant emphasis on service related to the combination and integration of data - e.g., geocoding, superposition of format and gridding. The Air Quality users in the UARS program and the Geodynamics users specified the wish to retain control over access of their data by other users.

Additional services required by individual disciplines yielded the following ADS service requirements:

- Data ordering and procurement services are useful adjuncts to the catalog and inventory service. Currently, investigators gather their required data from a wide variety of basically unarchived and unannotated sources. Dealing with a variety of data banks is time consuming: the users universally express the need for a centralized facility from which they can locate and acquire the bulk of the data which they require.

- Data are available in a variety of formats which require coregistration. Much of this diversity in format is attributed to the current absence of any format standards in the geodynamic field. Proliferation of different formats unnecessarily increases overhead related to reformatting by both investigators and data system.

  ADS could significantly impact this problem by limiting the proliferation of varying data formats to those necessitated by efficiency or by compatibility with existing systems.

- Remotely sensed data products are generally viewed by operational users as supportive and complementary to the more readily understood and handled conventional data sets. Increased emphasis should be devoted to converting satellite data products into conventional formats to aid technology transfer activities.

Satellite products should be processed and georeferenced in accordance with the conventional data products which they supplement.

An ADS service would significantly enhance the day to day operation of the OSTA research user community by:

- Speeding up data delivery - slow data deliveries impact the budget and the efficiency of the R&D effort.
- eliminating or significantly reducing the time spent in locating, selecting, editing and procuring data
- reducing expenditures for redundant handling of data products
- providing for better oversight by the scientific user community to provide higher data quality
- providing pre-operational users with standard, approved, parameter and analysis algorithms
- creating a highly visible and easily accessible archive of space derived products for both internal researchers and external users
- significantly increasing the cost-effectiveness of OSTA data utilization through standardization of format and the availability of researcher independent reformatting

Potential ADS services leading to overall efficiency of OSTA research are:

- A data cataloging service would speed data access and would enhance investigators' awareness of data to support their studies. The catalogs should be comprehensive as to breadth and content of information in each data set. Hierarchical descriptors should be provided to accommodate various levels of user required data. The initial access level would contain the generic identification (e.g., name, source, location, period of record, measured or derived quantities/parameters) for each data set.

Subsequent hierarchial levels would enable potential data users to browse and review the data set contents. Information at this level should include; data set characteristics, such as resolution and level of reduction, quality control steps applied, data limitations and restrictions on data set usage, data volume and form, data availability for a specific location, and appropriate cross-references to related data sets.

The next level of information should include detailed descriptions of instrument operations, data collection procedures, processing algorithms, and validation results.

Catalogs should also be available to identify available software routines, data interpretation/manipulation tools and techniques.

Discussion at the ADS workshop indicates that such a catalog service would be best implemented in a distributed manner. Separate catalogs should be maintained by the individual data producer archives, with the access capability from the central catalog facility. The distributed nature of the catalog service should be as transparent to users as possible. A user-oriented interface for obtaining catalog information should be a major objective of an ADS. This requires that a access/query capability be designed for ready-use by even uninitiated users. A request processing capability should provide the contact point for initial inquiries.

A request routing capability should be provided internal to the system but be user-transparent.

Key issues of importance that must be resolved during the development of an ADS catalog service are:

- Establishment of standards
- Generation of catalog contents for past data and updating procedures for current data

- A data extraction/assembly service would reduce the time and expense required by researchers in acquiring and integrating the multi-source data sets. This service would provide standardized multi-source and multi-temporal data set preparation, data set sorting and merging, and data segment preparation. Important facets of this service are data reformatting and integration services.

Reformatting entails conversion of data from one form (digital, analog, textural, tabular or graphic) to another to satisfy user requirements. Also included are code, coordinate and scale conversions.

Data integration entails elements of both data set preparation and reformatting. Potential processing operations required to convert disparate data to a common form and scale include:

a) multi-sensor, unitemporal and multitemporal registration, entailing the congruencing and rescaling of data of different scale and aspect angles;

b) geographic referencing;

c) coordinate transformations, for example space oblique mercator to universal transverse mercator;

d) data overlay and gridding;

e) mosaicing, in which adjacent swaths of space or airborne imaging sensors are equalized radiometrically, congruenced, rescaled, and laterally registered.

- Centralized accounting, scheduling and data traffic monitoring; serve to maintain track of user's expenditures, and to supply budgetary estimates.

- Centralized facilities for processing data into parameters. Development of parameter processing techniques should be handled as a phased program, for key time persistent parameters. The capability for scientific oversight, data quality control assessment and parameter algorithms development and archiving should also be provided.

- Data delivery to users in user requested format with a factor of three speed up for auxiliary products.

- Establishment and maintenance of an archive of products derived by OSTA discipline researchers. The archive should provide data cross-referencing and should be constructed to serve both the internal and external user community. Archives should include browse, on-line order transaction and message processing capabilities.

- Establishment of comprehensive data format, standards and protocols particularly required for the processing of multisource data sets.

- Provision for standard on-line and batch processing of requested data including specific data reformatting, resampling, and radiometric correction.

- The ADS service should be electronically linked into the major auxiliary data systems services in particular: EDIS, USGS National center and NAWDEX.

- The nature of many of the OSTA Disciplines make it advantageous to provide an archive of processed intermediate products both to support multiple investigations and for historical purposes.

- The availability of standard classification schemes and parameter extraction algorithms from a centralized facility would enhance researcher performance. The classification algorithms and procedures should be carefully annotated as to input requirements, utility and be provided with appropriate caveats as to applicability, time to process and expected performance accuracies. An interactive user-training capability would probably be a useful adjunct. The facility would have to maintain continuous updates on classification schemes and algorithms and process online.

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GLOSSARY

DATA BANKS

AFGWC	Air Force Global Weather Central
ASCS	Agriculture Stabilization and Conservation Service
CCEA	Center for Climatic and Environmental Assessment
CDHF	Command Data Handling Facility (JPL-SEASAT)
CRIS	USDA - Current Research Information System
DBO	NOAA - Data Buoy Office
DMA (DMATC)	Defense Mapping Agency
DMSP	Defense Meteorological Satellite Program
DOC	U.S. Department of Commerce
EPA	U.S. Environmental Protection Agency
EPA/ERC	U.S. Environmental Protection Agency/Environmental Research Center
EPRI	Environmental Protection Research Institute
EROS	Earth Resource Observations System (Sioux Falls, S.D.)
ESOC	European Space Operations Center
FAA	Federal Aviation Administration
FAS	USDA - Foreign Agricultural Service
FNWC (USNFNWC)	Fleet Numerical Weather Central
GADG	Global Agricultural Data Base (Johnson Space Center)
GISS	Goddard Institute for Space Studies
GSFC/IPD	Goddard Space Flight Center/Information Processing Division Center
GSFC/IPF	Goddard Space Flight Center/Image Processing Facility
JAWF	Joint Agricultural Weather Facility
JPL	Jet Propulsion Laboratory (Pasadena, California)
JSC	Johnson Space Flight Center
LARS	Laboratory for Applications of Remote Sensing
NASA	National Aeronautics and Space Administration
NAWDEX	National Weather Data Exchange
NCAR	National Center for Atmospheric Research
NCC	National Climatic Center (Asheville, N.C.)
NCC/SDS	National Climatic Center/Satellite Data Service
NCIC	National Cartographic Information Center
NESS	National Environmental Satellite Service (NOAA)
NFWF	Naval Fleet Weather Facility
NGS	National Geodetic Data Base
NGSDC (NGSTDC)	National Geophysical and Solar-Terrestrial Data Center
NHC	National Hurricane Center
NMC	National Meteorological Center (Suitland, MD)
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NODC	National Oceanographic Data Center
NOSS/PPF	National Ocean Satellite System/Primary Processing Facility
NSSDC	National Space Science Data Center
NSSL	National Severe Storms Laboratory
NSSFC	National Severe Storms Forecast Center
NWS	National Weather Service (U.S. Department of Commerce)
SCRIPPS	Scripps Institute of Oceanography
SCS	USDA - Soil Conservation Service
SEDIC	Sociological Economic Demographic Information Center
STORET	U.S. Environmental Protection Agency Water Quality Data Bank
TAMU	Texas A&M University
TELOPS	Telemetry On-Line Processing System
UARS/CDHF	Upper Atmospheric Research Satellite/Central Data Handling Facility
USAFETAC	U.S. Air Force Environmental and Technical Applications Center
USCG	U.S. Coast Guard
USDA	United States Department of Agriculture
USDA/ESCS	USDA/Economic Statistics and Cooperative Services
USDA/FS	USDA/Forest Service
USGS	U.S. Geological Survey
VLBI	Very Long Baseline Interferometer
WFC	Wallops Island Space Flight Center
WHOI	Woods Hole Oceanographic Institution
WATSTORE	USGS/Water Data Storage and Retrieval System
WESLACO	USDA/Agricultural Test Station (WESLACO TX)

PLATFORMS

AEM	Applications Explorer Mission
DMSP	Defense Meteorological Satellite Program
COASTSAT	Coastal Zone Satellite
ERBS/AEM	Earth Radiation Budget Experiment
GEOS	Geodynamic Experimental Observation Satellite
GOES	Geosynchronous Operational Environmental Satellite
GRAVSAT	Gravity Satellite
ICEX	Ice and Climate Experiment
ITOS	Improved Tiros Operational Satellite
LAGEOS	Laser Geodynamic Experiment Observation Satellite
LANDSAT	Earth Resources Satellite for Land Areas
MAGSAT	Magnetic Survey Satellite
METEOSAT	Meteorological Satellite
NOAA	National Oceanic and Atmospheric Administration Satellite
NOSS	National Oceanographic Satellite System
OERS	Operational Earth Resources System
POGO	Polar Orbiting Geophysical Observatory
SEASAT	Landsat Counterpart for Ocean Areas
SPACE SHUTTLE	The NASA Manned Launching System (Space Transportation System)
STS	Space Transportation System (See Space Shuttle)
STORMSAT	Severe Storm Monitoring Satellite
SME	Solar Mesosphere Explorer
SMM	Solar Maximum Mission
SMS	Synchronous Meteorological Satellite
STEREOSAT	Stereoscope Imagery Satellite
THERMOSAT	Thermal Satellite System
TIROS	Television - Infrared Observation Satellite
TOPEX	Topographic Observation Experiment
UARS	Upper Atmosphere Research Satellite

GLOSSARY

SENSORS

AASIR	Advanced Atmospheric Sounding Infrared Radiometer
ACPL	Atmospheric Cloud Physics Laboratory
ALT	Altimeter
AMMS-AMMR	Advanced Moisture Mapping Sensor - Advanced Moisture Mapping Radiometer
AMS	Active Microwave Sensor
AVHRR	Advanced Very High Resolution Radiometer
BUV	Backscatter Ultraviolet Sensor
CLIR	Cryogenic Limb Inferometer
CP	Coronagraph/Polarimeter
CPR	Cloud Physics Radiometer
CTS	Cloud Top Scanner
CZCS	Coastal Zone Color Scanner
EFS	Electric Field Sensor
ER	Emission Radiometer
ERB	Earth Radiation Budget Sensor
ERBE	Earth Radiation Budget Experiment
ERSAR	Earth Resources Synthetic Aperature Radar
ESMR	Electrically Scanning Microwave Radiometer
FIS	Far Infrared Spectrometer
FMAG	Triaxial Vector Fluxgate Magnetometer
FR	Filter Radiometer
GRM	Global Regional Monitor
GRS	Gamma Ray Spectrometer
HALOE	Halogen Occultation Experiment
HCMR	Heat Capacity Mapping Radiometer
HIRS	High Resolution Infrared Radiation Sounder
HXIRS	Hard X-Ray Imaging Spectrometer
HXRS	Hard X-Ray Spectrometer
IEAS	Ice Elevation Altimeter System
IR	Infrared Sensor
ITPR	Infrared Temperature Profile Radiometer
LAMMR	Large Antenna Multifrequency Microwave Radiometer
LASER Reflector	Passive Reflector of Surface Laser
LBMR	L-Band Microwave Radiometer Soil Moisture Sensor
LFC	Large Format Camera
LHR	Laser Heterodyne Radiometer
LIDAR	Laser Radar
LIMS	Limb Infrared Monitor of the Stratosphere
LRIR	Limb Radiance Inversion Radiometer
LWS	Lidar Wind Sensor, DMSP
MAPS	Mapping of Atmospheric Particulates from Space (Sensor Package)
MASR	Microwave Atmospheric Sounding Radiometer
MES	Microwave Emission Spectrometer
MGCR	Modulated Gas Cell Radiometer
MI	Microwave Imager, DMSP
MLS	Microwave Limb Sounder
MPMR	Multifrequency Passive Microwave Radiometer
MRS	Multi-Spectral Resource Sampler
MSS	Multispectral Sensor
M^2S	Modular Multispectral Scanner
NEMS	Nimbus Microwave Spectrometer
NER	Nadir Emission Radiometer
NOSL	Nightime Observation of Severe Lightning
OCE	Ocean Color Experiment
OLS	Operational Linescan System
OR	Occultation Radiometer
OVS	Operational Vertical Sounder
PERS	Pointable Earth Resources Sensor
PES	Precipitating Electron Spectrometer
PFD	Particle Flux Detector
PIMR	Polar Ice Mapping Radiometer
PMIS	Passive Microwave Imaging Sensor
PMR	Pressure Modulator Radiometer
RBV	Return Beam Vidicon (camera)
SAGE	Stratospheric Aerosol Gas Experiment
SAM	Stratospheric Aerosol Measurement
SAR	Synthetic Aperature Radar
SASS	Seasat A Scanning Scatterometer
SBUV	Solar Backscatter Ultraviolet
SCAMS	Scanning Microwave Spectrometer
SCAT	Scatterometer
SCM	Solar Constant Monitor
SCMR	Surface Composition Mapping Radiometer
SCR	Selective Chopper Radiometer
SEM	Space Environmental Monitor
SIR	Shuttle Imaging Radar
SMIRR	Shuttle Multispectral Infrared Radiometer
SMMR	Scanning Multichannel Microwave Radiometer
SMS	Stratospheric and Mesospheric Sounder
SR	Scanning Radiometer
SSB	Low Energy Gamma Ray Detector, DMSP
SSH	Infrared Sounder, DMSP
SSIE	Ionospheric Sensor, DMSP
SSM	Microwave Imager, DMSP
SSR	Side Scan Radar
ST. TELE	Stereo Telescope
SUS	Solar Ultraviolet Spectrometer
SXRP	Soft-X-Ray Polychromator
THIR	Temperature Humidity Infrared Radiometer
TIS	Topside Ionospheric Sounder, DMSP
TM	Thematic Mapper
TOMS	Total Ozone Mapping Spectrometer
TOVS	TIROS Operational Vertical Sounder
UV	Ultraviolet Sensor
UVAS	Ultraviolet Airglow Spectrometer
UVSSF	Ultraviolet Spectrometer Solar Flux
UVSP	Ultraviolet Spectrometer and Polarimeter
VAS	Visible-Infrared Atmospheric Sounder
VHRR	Very High Resolution Radiometer
VIR	Visible-Infrared Radiometer
VIRSR	Visual and Infrared Scanning Radiometer
VISSR	Visual - Infrared Spin Scan Radiometer
VLBI	Very Long Baseline Interferometer
VTPR	Vertical Temperature Profiling Radiometer
WSIR	Wide Swath Imaging Radar
XUVS	Extreme Ultraviolet Spectroheliometer
XYPLS	X-Y Plane Limb Scanner, DMSP
XZPLS	X-Z Plane Limb Scanner, DMSP

GLOSSARY

TERMINOLOGY

A/C	Aircraft
ALBEDO	Ratio of light reflected from surface to light falling on surface
AN	Applications Notice
AO	Applications Opportunity
APT	Applications Pilot Test
NPI	Not Presently Identified
P	Phosphorous
PARM	SMMR Paramter Tape
PPB	Parts Per Billion
PPM	Parts Per Million
RAP	Regional Applications Program
REAP	Regional Environmental Assessment Program
REG WATER QUAL MON	Regional Water Quality Monitor
RR	Renewable Resources
RTOP	Research and Technology Objectives and Plans
SAT	Satellite
SRT	Science Research and Technology
T	Turbidity
TBA	To Be Announced
TEMP	Temperature
TSS	Total Suspended Solids
UV	Ultraviolet
VERT.	Vertical
% rh	Percent Relative Humidity
w/cm^2	Watts per square centimeter
ASVT	Applications Systems Verification Technology
BPI	Bits Per Inch
C	Centigrade
CBT	Calibrated Brightness Tape (See CBTT)
CBTT	Calibrated Brightness Temperature Tape (ESMR Product)
CC	Cubic Centimeter
CCT	Computer Compatible Tape
GARP	Global Atmospheric Research Program
GLOB/REG MON	Global/Regional Atmospheric Monitor
HOR.	Horizontal
HRS	Hours
I	Image
IR	Infrared
KM	Kilometer
LSAT	Large Scale Applications Test
LAS	Landsat-D Assessment System
LEVEL 0	Raw Data
LEVEL 1	Calibrated Data
LEVEL 2	Geo-coded Data
LEVEL 3	Derived Parameters
M	Meter
MEA	Measurement
MET	Meteorological
M GAL	Milligal
MM	Milimeter
MOU	Memorandum of Understanding
M/S	Meters/Second
NA	Not Applicable
NCP	National Climate Program
ND	Not Determined
NI	Not Included